LF/M03

MET O 3 TECHNICAL NOTE NO. 32

Monitoring the homogeneity of UK climatological data

by

F A Crummay

July 1985

Advisory Services (Met O 3)
Meteorological Office
London Road
Bracknell
Berkshire RG12 2SZ

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Summary

A program to test the homogeneity of climatological records is described and tested on temperature and sunshine. It has been devised to operate in conjunction with the production of 30 year averages and has two main uses:

i. the testing of station homogeneity prior to the publication of the 30 year averages.

ii. assisting in the selection of WMO reference climatological stations (RCS).

Results indicate that the majority of inhomogeneities consist of gradual changes in recorded temperature or sunshine although a few step changes have been identified and corrections suggested.

A separate section describes the results obtained with reference to the RCS and suggests possible alternatives.

Introduction

The quality control of meteorological data plays an important role in the establishment of a climatological data base. With the exception of rainfall, current procedures check for only large random errors in daily values, allowing smaller systematic errors to escape undetected. The exception, rainfall has a system of monthly and annual quality control operating on a similar basis to the daily routine and relying on the map of average annual rainfall (AAR). This procedure, however, is only suitable for the detection of over or under-estimates in a particular year.

At present the checking of station homogeneity, for long period averages for example, requires a long tedious examination of station site changes and observations, for the most part by hand. An alternative approach has been developed using neighbouring stations to produce estimates for each station over a long period of time (eg 30 years). A time series of the differences between the observations and the estimates (the residuals) is formed and subjected to statistical analysis to determine whether the series is stationary. This approach has two main applications:-

i. the detection of inhomogeneities prior to the publication of 30 year averages

ii. assisting in the choice of WMO reference stations.

The latter are defined as stations whose data are intended for the purpose of determining climatic trends and hence require long periods (not less than 30 years) of homogeneous records where man-made environmental changes have been and/or are expected to remain at a minimum.

The estimates required can be produced from surrounding stations by either regression or principal components, both techniques being capable of similar accuracy (Crummay, 1985). The regression technique involves

explicitly placing large weights on certain neighbouring stations, so that if these contain inhomogeneities they will be reflected in the estimates. Estimates were therefore obtained using a principal component analysis which is less likely to be heavily dependent on observations from a single neighbour. Neither regression nor principal components involve spatial interpolation and hence do not identify over or under-estimates which persist unchanged throughout the period of analysis.

The following work is similar to that undertaken by Done (1980). She used principal components calculated by Spackman for 600 daily stations in 1973-77 to analyse minimum temperatures at 125 long period stations for the period 1959-1977. Here, maximum temperature and sunshine are also considered while the principal components are calculated from the data analysed, which is for the period 1951-1980. It has been designed as a system to operate in conjunction with the production of 30 year averages.

Method

A principal component analysis requires a complete and self-consistent correlation or covariance matrix. The program has been designed to operate using data sets containing 30 years x 12 months of data from which missing values have already been eliminated. Such data sets are produced as part of the production of 1951-80 averages and described in M03 Technical Note 16 (pt B).

To reduce the storage space required and the computing costs, which are proportional to the cube of the number of variables, the UK was divided into 10 districts, this making little difference to the actual results (Tabony, 1984). Options are available to produce a T-mode or S-mode analysis, T-mode using months as variables, S-mode the stations.

The input data may consist of raw data or one of three types of anomaly.

a. Departures from the long period station mean, referred to as the 'station' anomaly.

b. Departures from the long period station means averaged over all stations in a given month, referred to as the 'local' anomaly.

c. Departures from a mean obtained by averaging the data over all stations for a given month, referred to as the 'monthly' anomaly.

Tabony (1984) considered that the type of anomaly selected made very little difference to the accuracy of the technique and for the following discussion an S-mode analysis was performed on the monthly anomalies.

The selection of the optimum number of components to use is a difficult problem. For the purposes of daily quality control, Tabony (1984) suggested that the number be set to 6% (temperature) and 8% (sunshine) of the total number of stations supplied. The differing percentages related to the number of, and correlation between stations and the frequency of errors in the data. In the current study stations with known inhomogeneities - either identified by Done or recorded in the station file, were used as indicators as to the number of components to use. Components representing 8% (temperature) and 12% (sunshine) of the number of stations were selected for general use since they identified the majority of these known inhomogeneities.

Residuals were calculated for all stations, but were only analysed for those for which more than 50% of observations were available. The residuals were then divided into two groups as follows:-

i. first 5 and last 25 years.

ii. first 10 and last 20 years

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vi. first 25 and last 5 years

Each pair of subsets were subjected to a t test and any stations with significant differences at the 5% level were flagged and, to aid clarity, the annual means of their residuals plotted. The procedure is documented in Appendix 1.

Results

The data analysed included 577 stations for temperature and 391 stations for sunshine for which data was available for at least 10 years in the period 1951-80. Homogeneity tests were only performed on those stations for which 15 years of data were available, this requirement reducing the number of stations to 442 for temperature and 309 for sunshine. Queries were raised for 39 stations for sunshine, 111 stations for maximum temperature and 107 stations for minimum temperature.

From the plots of the residuals it was apparent that the majority of inhomogeneities consisted of gradual changes in recorded temperatures and sunshine although a few clear discontinuities have been illustrated in Fig. 1 and Fig. 2 and corrections suggested where possible. These gradual changes may have several causes

i. changes in site exposure or character eg. by the the growth of trees or urbanisation.

ii. deterioration of screen or instruments.

iii. small changes in site or varying accuracy between observers - not sufficient to cause a marked step but several such changes may suggest a trend to the casual observer.

One notable inhomogeneity identified by this process is the changes in site for the Cardiff sunshine recorder. In 1960 the growth of trees at the initial site led to a decrease in observed sunshine of approximately 80 hours per annum. The recorder was moved and values returned to their

previous levels. However in 1967 the recorder was again moved, to Ty Twyn, a poor site obscurred by trees. The level of sunshine recorded fell by 125-150 hours per annum (20-25 mins per day) until the station ceased in 1976. All these changes and the growth of trees at the initial site are clearly illustrated in Fig. 2.

Roy (per comm. 1984) suggested a list of 28 Scottish stations which were considered to have suffered no significant site changes (Table 1). In the light of this it was decided to study these stations to determine whether other factors may have caused inhomogeneities. 17 out of the 28 stations were flagged by the routine (Fig. 3) although Craibstone (DCNN=1272) may be considered as almost homogeneous with the slope of 0.2°C over the 30 years, less than the accuracy to which instruments may be read. Stations with a change of $\pm$ 0.5°C over the period studied include Arbroath, Greenock, Blackford Hill (max temp) and Achnashellach. Blackford Hill (min temp), Nairn and Cape Wrath all show an even more marked slope and in Fig. 4 the genuine data for Blackford Hill illustrates the trend as identified by the residuals. Dundee and Cape Wrath show discontinuities in the first 6 years of the data set.

In addition, one station, Onich (DCNN=0561) was known to have become progressively more sheltered by trees during the study period. The station inspectors decided that these had no significant effect on the mean temperatures recorded. Fig. 5 however, disputes this claim. Both the maximum and minimum temperature residuals show marked slopes. The decrease in maximum temperatures and increase in minimum temperatures may be due to the sheltering effect of the trees, particularly in this coastal site.

TABLE 1 Scottish stations considered to have suffered no significant site changes 1951-80

STATION	DCNN
Baltasound	0088
Kirkwall	0154
Wick	0293
Cape Wrath	0329
Stornoway	0425
Achnashellach	0436
Fortrose	0482
Benbecula	0516
Kinloss	1057
Braemar	1215
Balmoral	1226
Abbotsinch	6379
Auchincruire	6544
Dumfries	6641
Craibstone	1272
Aberdeen (Mannfeld)	1280
Dundee (College Gardens)	1361
Arbroath	1393
Leuchars	1577
Turnhouse	1634
Edinburgh - Blackford Hill	1646
Edinburgh - Royal Botanic Gardens	1649
Dunbar	1699
Tiree	6007
Greenock	6318
Paisley	6366
Glenlee	6745

WMO reference stations

The study of long period climatic trends obviously requires a consistent record of climatological data from a representative network of stations. In the 1950's the UK Meteorological Office devised the term 'key climatic station' to represent stations whose data was to be used to provide a long series of observations for use as climatological reference standards. A number of principal climatological stations (PCS) were selected to fit this criterion and in the 1970's, when the WMO suggested the designation of certain sites as reference climatological stations, these formed the basis of the initial selection.

This initial selection, based on PCS presumably since the Met Office could retain some measure of control over them, consisted of:-
Lerwick, Stornoway, Leuchars, Eskdalemuir, Aldergrove, Leeming (Dishforth), Ringway, Valley, Honington (Mildenhall), Heathrow, Kew, Edgbaston, Mount Batten and Ross-on-Wye. ( ) indicate stations which closed.

One of the main criteria for such stations, however, is the homogeneity of records of at least 30 years length and in 1981/2 the above list was modified to include other stations which, despite not being PCS, were considered to qualify as reference climatological stations. Replacements for those stations no longer considered suitable or which had ceased were also nominated. The new list consisted of:-

Aldergrove	Armagh	Auchincruive
Benbecula	Braemar	Cambridge (NIAB)
Dale Fort	Eskdalemuir	Falmouth
Ilfracombe	Lerwick	Leuchars
Malvern	Mount Batten	Ryde
Squires Gate	Tynemouth	Valley
Wick	Wye	Waddington

together with a second list of stations to be monitored and considered as future reference stations.

The homogeneity of such records (temperature, sunshine, rain and wind) is difficult to control or monitor as many small site changes go un-noted whereas other larger moves may have no noticeable effect on the records. As a part of the analysis of the 1951-80 records it was decided to analyse those climatological variables available for the RCS, whether on the initial list or the updated revisions. Unfortunately wind and rain data have not been analysed and therefore a full picture is not available.

Of the original WMO reference stations, Stornoway (0425) was known to contain inhomogeneities in its temperature record due to changes in site. The most marked of these occurred in 1973 and is clearly illustrated in Fig. 6 for maximum temperature. Studies of the actual observations indicate that mean annual corrections of -0.3°C for maximum temperature and approximately +0.35°C for minimum temperature should be made to readings before 1973, with a greater confidence in the maximum correction than the minimum. Indeed, the minimum temperature inhomogeneity was sufficiently masked as to prohibit identification. For the maximum temperature, however, the residuals decreased by ~0.25-0.3°C between the two sections of record.

Edgbaston (4406), another of the original RCS, closed in 1979 and has been flagged as inhomogeneous prior to that date for minimum temperatures. This inhomogeneity consists of four years when minimum temperatures were ~0.2°C lower than expected and can probably be disregarded.

Ringway (7377) shows a 0.75°C increase in residuals over the 30 year period for minimum temperature. The site enclosure, located in Manchester (Ringway) Airport was thought to be homogeneous by Done (1980) although doubts had been raised as to the effects of increased urbanisation in the

surrounding area and the effects of passing aircraft. The general upward trend would suggest that urbanisation was having some effect (at least with respect to minimum temperatures) which a direct comparison of the annual mean minimum temperatures at Macclesfield would seem to support (Fig. 7).

Within the present list of RCS several queries were also raised. Some, for example Tynemouth (2091) and Waddington (2423) may be considered as relatively insignificant trends or, in the latter case, isolated events which do not influence the overall view (Fig 8). Other stations however, which have previously been considered homogeneous are subject to question, for example Kinloss (1057), which has a marked inhomogeneity with respect to sunshine (Fig. 9) in 1961.

Braemar (1215) is a relatively isolated site, usually compared with its only close neighbour, Balmoral. Indications suggest that Balmoral may be slightly inhomogeneous with respect to minimum temperatures and it has been considered difficult to check the homogeneity of the Braemar record, although frequents comments have been made with respect to its poor site. Fig. 10 indicates a general upward trend in maximum temperatures, but for sunshine a clear discontinuity is apparent for 1961/63 indicating a possible site change.

Leuchars (1577) (Fig 11) has also been considered homogeneous for temperatures, but a site change in 1959 is evident in the minimum temperature residuals with a sudden drop, followed by a rise again after 1962/3. A site change in 1969 has very little impact.

Auchincruive (6544) also illustrates an apparent change of site or site exposure in Fig. 12 where a clear increase in sunshine residuals of ~70 hours per annum occurs in 1957/58. The temperature residuals do not illustrate any such marked inhomogeneities but the minimum temperatures do appear to trend upwards by ~0.5°C over the 30 years.

Other RCS which appear to contain inhomogeneities include Valley (7511) (Fig. 13) and Armagh (9336) (Fig. 14) with Cambridge - NIAB (3254) and Exeter (8884) apparently inhomogeneous for sunshine alone (Fig. 15). The second list of RCS therefore has been reduced to 14 stations, mostly on the west side of the country. Before any firm decisions as to suitable alternatives can be made the history of each station together with its future need to be examined. For the period 1951-80, however a list of stations found to be homogeneous for all three elements examined is available (Appendix 2) and from this list possible alternative RCS have been suggested (Fig. 16).

Discussion

Tabony (1980) examined trends in rainfall for 1911-1970 at rainfall stations in the UK. He showed that trends ranged from -4.0 to +5.9% per decade, three times the range that might be expected by chance. Similar results have been observed for the climatic variables analysed in this study. Only 30% (temperature) or 40% (sunshine) of stations with in excess of 21 years data were deemed homogeneous (Fig. 17), these percentages rising to 57% and 69% respectively when only 15 years of data are available. The majority of these inhomogeneities consist of slow changes in site and instrumentation which are impossible to prevent; only a very small proportion of inhomogeneities were step changes which could be easily corrected.

This work is seen to have two clear uses

i. the identification of inhomogeneous site changes prior to the publication of 30 year averages.

ii. assisting in the selection of WMO reference stations - both past and future.

The present work, based in conjunction with the 1951-80 averages has suggested that such a study is necessary in the case of (i) above with several markedly inhomogeneous stations published with an unrepresentative 30 year average. The procedure could be adapted to analyse a longer time period but with the present limitation of data in machineable form this is too onerous a task. With reference to (ii) above, this procedure could be utilised every 10 years to provide a continuous check on the long term homogeneity of stations, particularly reference stations.

References

Crummay, F.A. 1985 'The estimation of missing values from highly correlated data. Met O 3 Tech. Note No. 31, Meteorological Office - unpublished.

Done, A.L. 1980 'Monthly mean minimum temperatures 1959-77: coefficients of a set of factors and station residuals'. Met O 3 Tech. Note No. 4. Meteorological Office - unpublished.

Tabony, R.C. 1980 'Urban effects on trends of annual and seasonal rainfall in the London area'. Met. Mag. Vol. 109 pp 189-202.

Tabony, R.C. 1984 'The quality control of daily sunshine' - private communication.

APPENDIX 1 DOCUMENTATION FOR PROGRAM QDHOMO

Program	QDHOMO
Source	MO3.BRANCH.FORT(QDHOMO)
Object	MO3.BRANCH.OBJ(QDHOMO)
Programmer	F.A. Crummay
Date	July 1985

Purpose

To monitor the homogeneity of climatological data in conjunction with the production of 30 year averages.

Method

A principal component analysis is performed on the dataset from which missing values must have been estimated. The data are estimated using 8% of the components for temperature and 12% for sunshine. A time series of the residuals is formed and divided into two subsets (ie first 5 years, last 25; first 10 years, last 20, ... first 25 years, last 5). The means of these subsets are compared using a t-test and a flag raised if the value exceeds a specified critical level (ISIG).

Input

The routine has been devised to operate on a data set (30 years x 12 months) of climatological data. Such data sets are produced in conjunction with the production of 1951-80 averages and described in MO3 Technical Note No. 16 (pt B).

Input data consists of the following integer*4 variables.

IVAR - defines the mode of analysis to be performed = 0 for variable = station, 1 if variable = month.

IAVE - defines the type of anomaly input into the PCA, = 0 for 'station' anomaly, 1 for 'local' anomaly, 2 for 'monthly' anomaly.

IPRINT - 1 to print all results, = 0 to print selected results.

IF1R, ILAS - first and last district to be analysed (ie if IFIR = 0 and ILAS = 0, district 0 studied ; IFIR = 0, ILAS = 1, districts 0 + 1 studied).

IDAR - determines the percentage of estimated data permitted 1 = 50%, 2 = 30%.

ITYPE - 1 to illustrate inhomogeneous stations, = 0 illustrate all stations.

IMULT - is determined by the type of data set to be analysed, = 1 for max and min temperature, = 2 for sunshine.

ISIG - determines the significance level at which values are to be tested, 1 = 95%, 2 = 90%.

Output

The mean annual residuals of the flagged stations are plotted on CALCOMP film with an option available (ITYPE) to plot the residuals for all stations.

Paper or microfiche output is also produced with, in all cases the mean annual residuals for the flagged stations, together with the t values and eigenvectors/values illustrated.

In addition IPRINT=1 results in the printing of the covariance matrix (15 by 15 variables), the monthly estimates (following PCA) and monthly residuals.

JCL

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.
//LKED.PBS DD DSN=MET.PROGLIB,DISP=SHR
//LKED.FAD DD DSN=MO3.BRANCH.OBJ,DISP=SHR
//LKED.CAL DD DSN=MET.CALCOMP,DISP=SHR
//LKED.MO3LOAD DD DSN=MO3.BRANCH.LOAD,DISP=SHR
//LKED.SYSIN DD *
        INCLUDE FAD(QQMESK,QDHOMO)
        INCLUDE PBS(GPRW,MWRIT)
        INCLUDE CAL(CALCOMP,LINE,SCALE,AXIS)
        INCLUDE MO3LOAD(CNAME)
//GO.FT06001 DD SYSOUT=A
//GO.FT07001 DD  SYSOUT=A,DCB=(RECFM=FB,LRECL=131,BLKSIZE=1310)
//GO.ARCHIV10 DD DSN=MO3.QQTMINM,DISP=SHR
//GO.FT08001 DD SYSOUT=G,DCB=(RECFM=FB,LRECL=80,BLKSIZE=1680)
//GO.STNAME DD DSN=MO3.CNTLDATA(MWRSTN82),DISP=SHR
//GO.SYSIN DD *
   0 2 0 0 0 2 1 1 1
//
```

Underlined sections to be changed if necessary.

Costs

The costs involved in running the routine are proportional to the number of variables. For 32 stations over 360 months and for one meteorological variable costs varied from an average of 58 units using T mode analysis to 12 units using S-mode.

APPENDIX 2 STATIONS IDENTIFIED AS HOMOGENEOUS FOR MAXIMUM AND MINIMUM TEMPERATURES TOGETHER WITH MONTHLY SUNSHINE (1951-80)

STATION	DCNN	FIRST OBS	STATION CLOSED	NOTES
70% of data - 3 elements				
Lerwick (S Screen)	0044	1939		WMO ref stn
Baltasound	0088	1904		WMO ref stn
Kirkwall	0154	1950		
Wick	0293	1873		WMO ref stn
Benbecula	0516	1942		WMO ref stn
Fort Augustus	0575	1883		
Inverness	0588	1958		
Aberdeen	1280	1949		
Mylnefield	1351	1954		
Perth	1482	1914	1979	
Penicuik	1641	1944	1983	
Dunbar	1699	1930		
Durham	2165	1851		
High Mowthorpe	2337	1951		
Bridlington	2387	1952	1980	
Lincoln	2425	1945		
Skegness	2494	1903		
Terrington St Clement	3007	1935		
Burlingham	3084	1948	1975	
Bradford	4045	1908		
Buxton	4112	1875		
Derby	4172	1955	1983	
Sutton Bonington	4201	1924		

Watnall	4206	1942		
Nottingham	4223	1882		
Warsop	4237	1952		
Newtown Linford	4316	1958		
Shipston-on-Stour	4441	1939	1982	
Elmdon	4447	1969	1981	
Moreton Morrell	4463	1953		
Stone	4636	1953		
Ross-on-Wye	4882	1914	1975	Reopened 1985
Cheltenham	4967	1874		
Hampstead	5028	1910		
Greenwich	5076	1907		
Heathrow	5113	1947		
Hampton	5131	1949		
Wisley	5237	1904		
Kew (NWS)	5259	1868	1980	
Gatwick	5271	1958		
East Malling	5336	1925		
Wye	5375	1924		WMO ref stn
Margate	5399	1882		
Brighton	5441	1947	1981	
Eastbourne	5471	1946		
Bexhill	5480	1908		
Hastings	5490	1934		
Everton	4631	1953		
Leckford	5647	1935		
Martyr Worthy	5666	1955		
Southsea	5670	1900		

Hayling Island	5680	1954		
Long Sutton	5687	1923		
Ventnor Park	5771	1926		
Shanklin	5782	1947		
Ryde	5798	1914		
Lyneham	5848	1945		
Marlborough	5877	1864		
Tiree	6007	1926		
Paisley	6366	1884		
Eskdalemuir	6679		S Screen only since 1971	
Newton Rigg	7071	1903		
Moor House	7188	1952	1980	
Squires Gate	7213	1942		WMO ref stn
Helmshore	7275	1952	1981	
Rhyl	7408	1899		
Trawscoed	8076	1950		
Dale Fort	8122	1950		WMO ref stn
Carmarthen	8235	1961		
Llandrindod Wells	8314	1935	1974	
Llwynon	8362	1952	1979	
Porthcawl	8431	1950		
Tredegar	8507	1950	1974	
Newport (Mon)	8532	1952	1977	
Hawkridge	8603	1958		
Hartland Point	8807	1938	1983	
Mount Batten	8811	1920		WMO ref stn
Ilfracombe	8829	1912		WMO ref stn
Torbay (Torquay)	8864	1930		

Starcross	8873	1948		
Culdrose	8922	1960		
Falmouth	8942	1869		WMO ref stn
Newquay	8946	1891	1982	
St Mawgan	8957	1955		
Bude	8987	1913		
Aldergrove	9142	1926		WMO ref stn

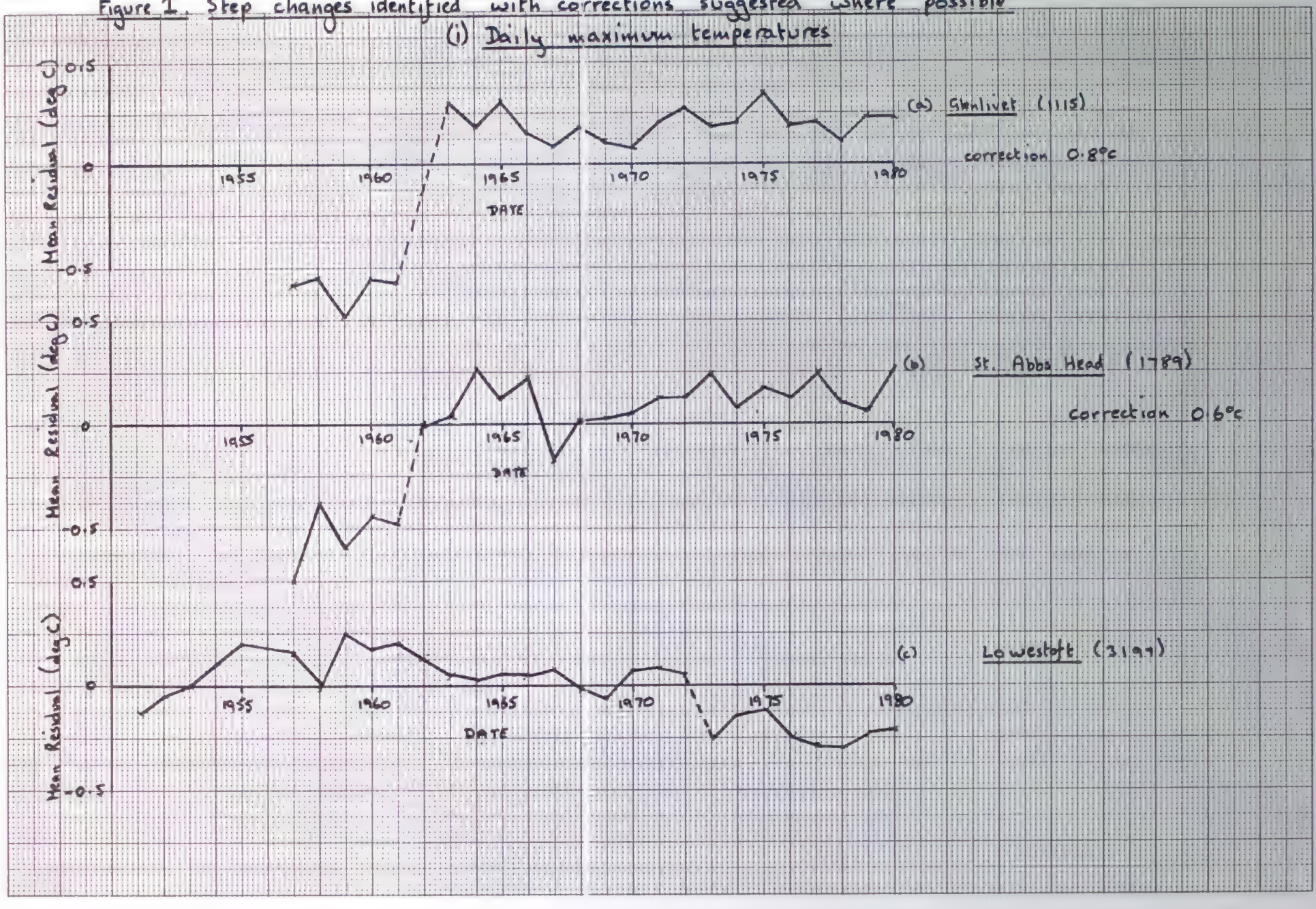
STATION	DCNN	FIRST OBS	STATION CLOSED	NOTES
50% of data - 3 elements				
Hamnavoe	0032	1961	1972	
Stenness	0144	1961	1974	
Dounreay	0208	1958		
Strathy	0388	1939	1976	
Poolewe	0434	1961		
Kinlochewe	0445	1953		
Grantown-on-Spey	1042	1965		
Elgin	1078	1965	1982	
Dinnet	1242	1962	1982	
Fyvie Castle	1267	1956		
Rattray Head	1297	1946	1967	
Stonehaven	1324	1909		
Carnoustie	1382	1950	1978	
Usan	1397	1965	1979	
Drummond Castle	1444	1969		
Blairgowrie	1483	1960	1978	
Kinross	1516	1967		
Kirkcaldy	1551	1950	1979	
Davidson's Mains	1638	1949	1970	
Galashiels	939	1967		
Sourhope	1993	1951	1974	
Acklington	2086	1943	1975	
Leeming	2245	1965		
Ampleforth	2264	1904	1972	
Whitby	2289	1939		
Scarborough	2292	1873	1971	

Mildenhall	3107	1935	1968
Brooms Barn	3115	1964	
Garston	3534	1961	1982
Huddersfield	4041	1922	1977
Bramham	4076	1952	
Pershore	4834	1953	1977
Throwley	5365	1950	1975
Folkestone	5381	1905	
Dover	5390	1873	1976
Littlehampton	5420	1915	1979
Rustington	5421	1960	
Worthing	5431	1852	1971
East Hoathly	5464	1963	
Bodiam	5488	1939	1975
Wallingford	5338	1960	
Bournemouth	5601	1892	1978
Southampton (East Park)	5643	1853	1969
Machrihanish	6040	1965	
Earls Hill	6276	1961	1980
Camps Reservoir	6483	1963	
Carlisle	7050	1960	
Stonyhurst	7269	1851	1978
Nelson	7288	1940	1979
Ruthin	7657	1959	
Botwnnog	7713	1960	
Port Talbot	8421	1952	1979
Usk	8555	1924	1980
Poole	8785	1933	

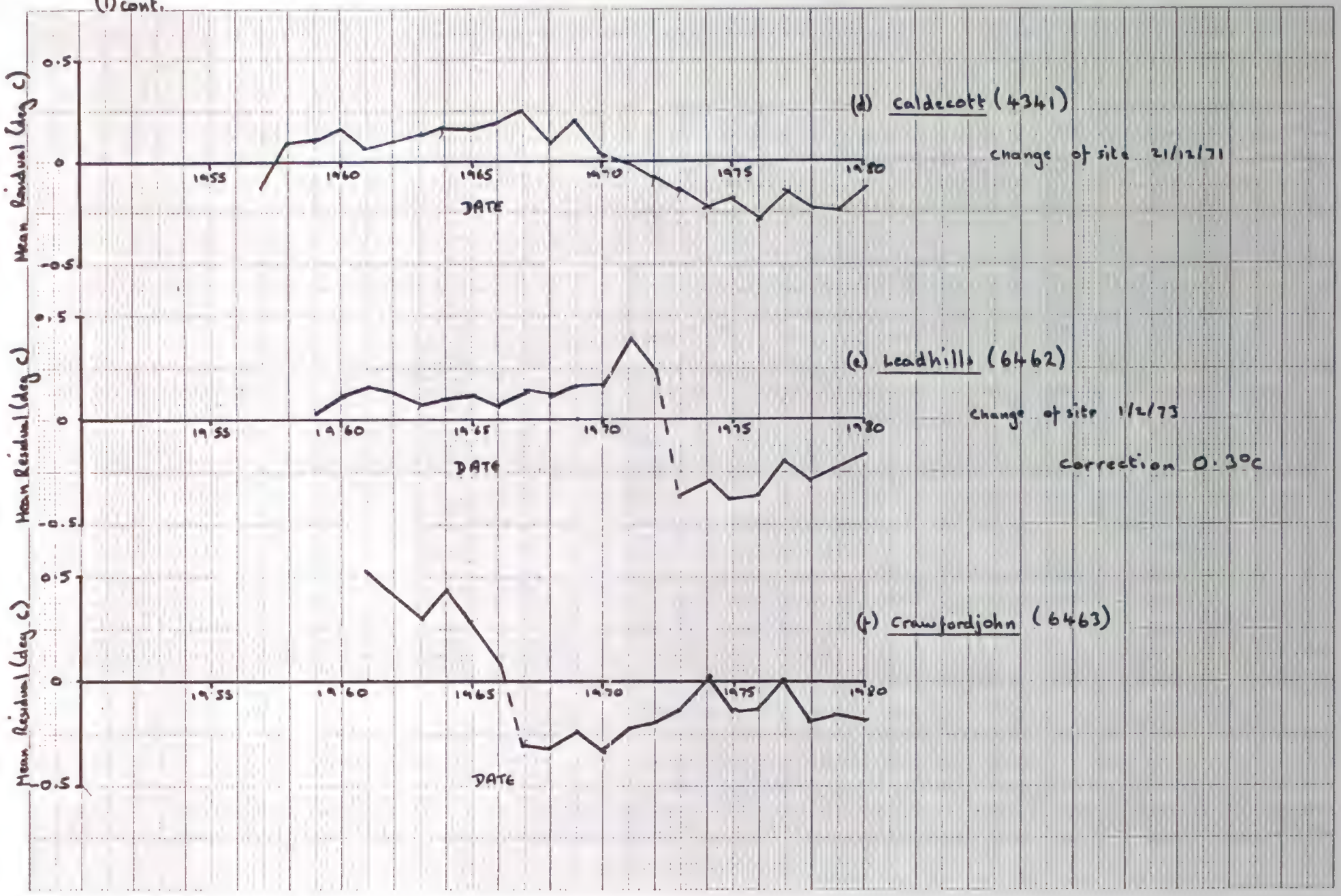
Chievenor	8827	1943	
Lizard	8930	1932	
Lowtown	9167	1965	
Ballypatrick Forest	9169	1961	
Castle Archdale Forest	9547	1962	
Alderney	9947	1957	1979

60 stations

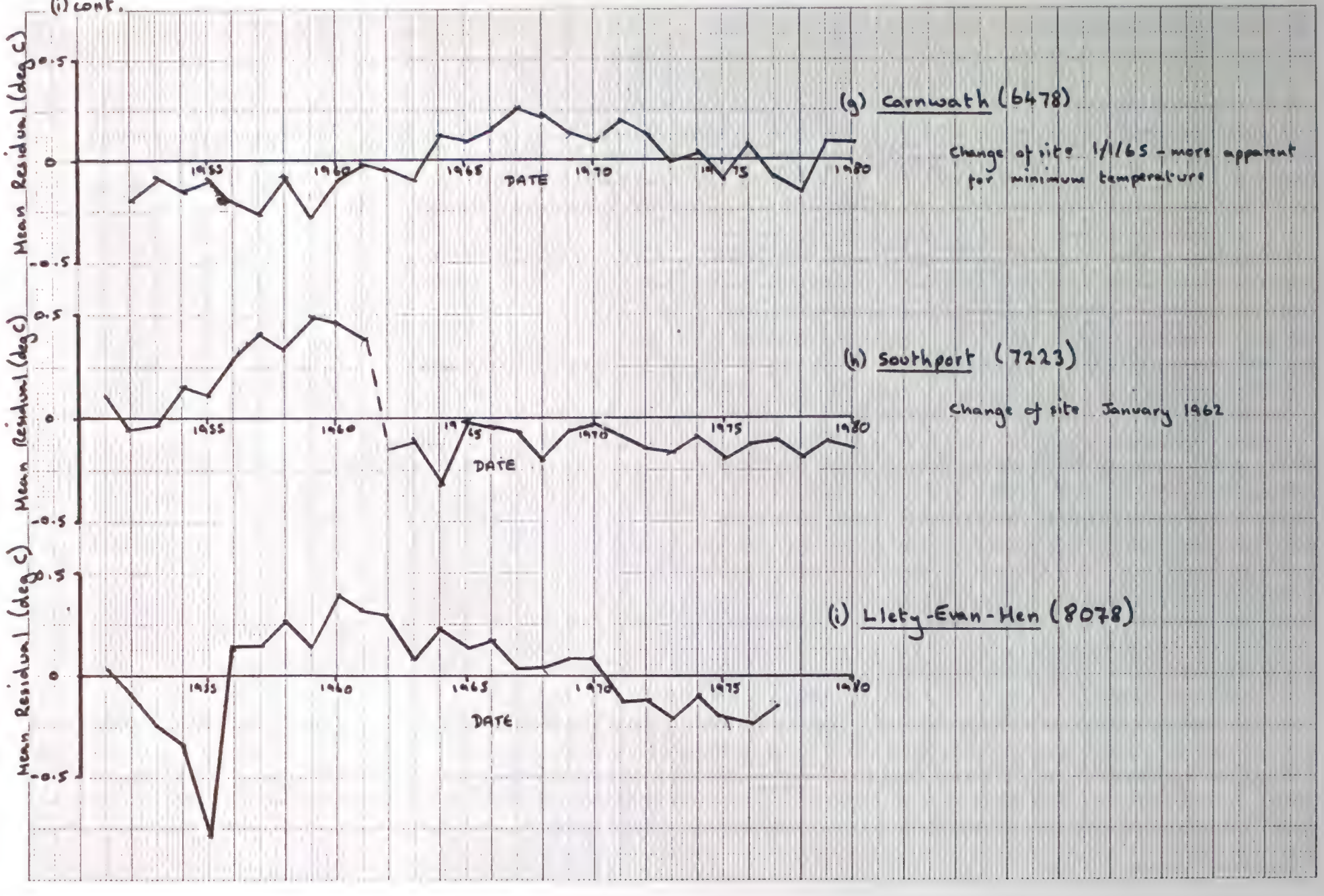
Figure 1. Step changes identified with corrections suggested where possible



(i) cont.


(d) Caldecott (4341)
change of site 21/12/71
(e) Leadhills (6462)
change of site 1/2/73
correction 0.3°C
(f) Crawfordjohn (6463)
Mean Residual (deg C)
0.5
0
-0.5
1955
1960
1965
1970
1975
1980
DATE

(i) cont.



(g) Carnwath (6478)

Change of site 1/1/65 - more apparent for minimum temperature

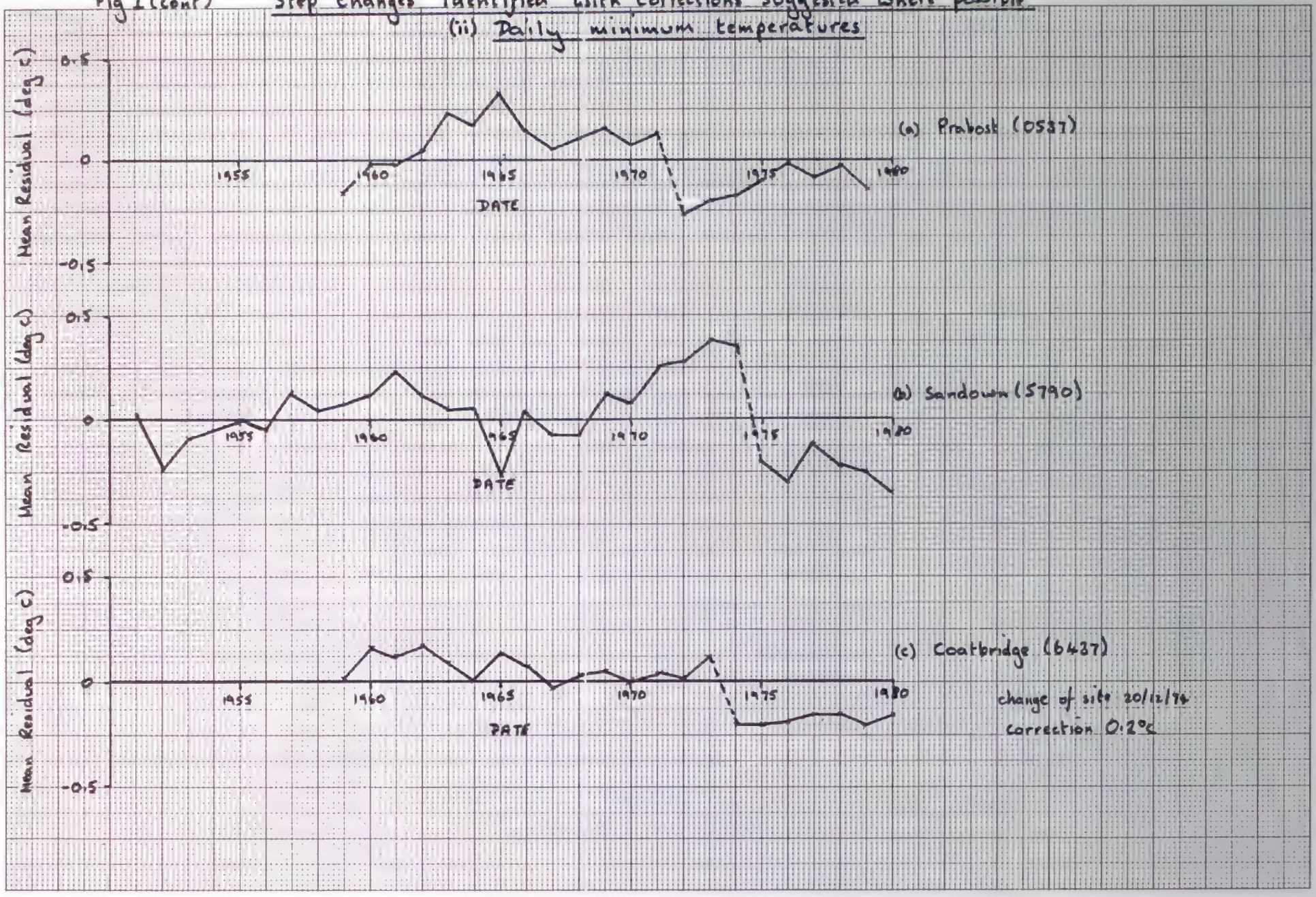
(h) Southport (7223)

Change of site January 1962

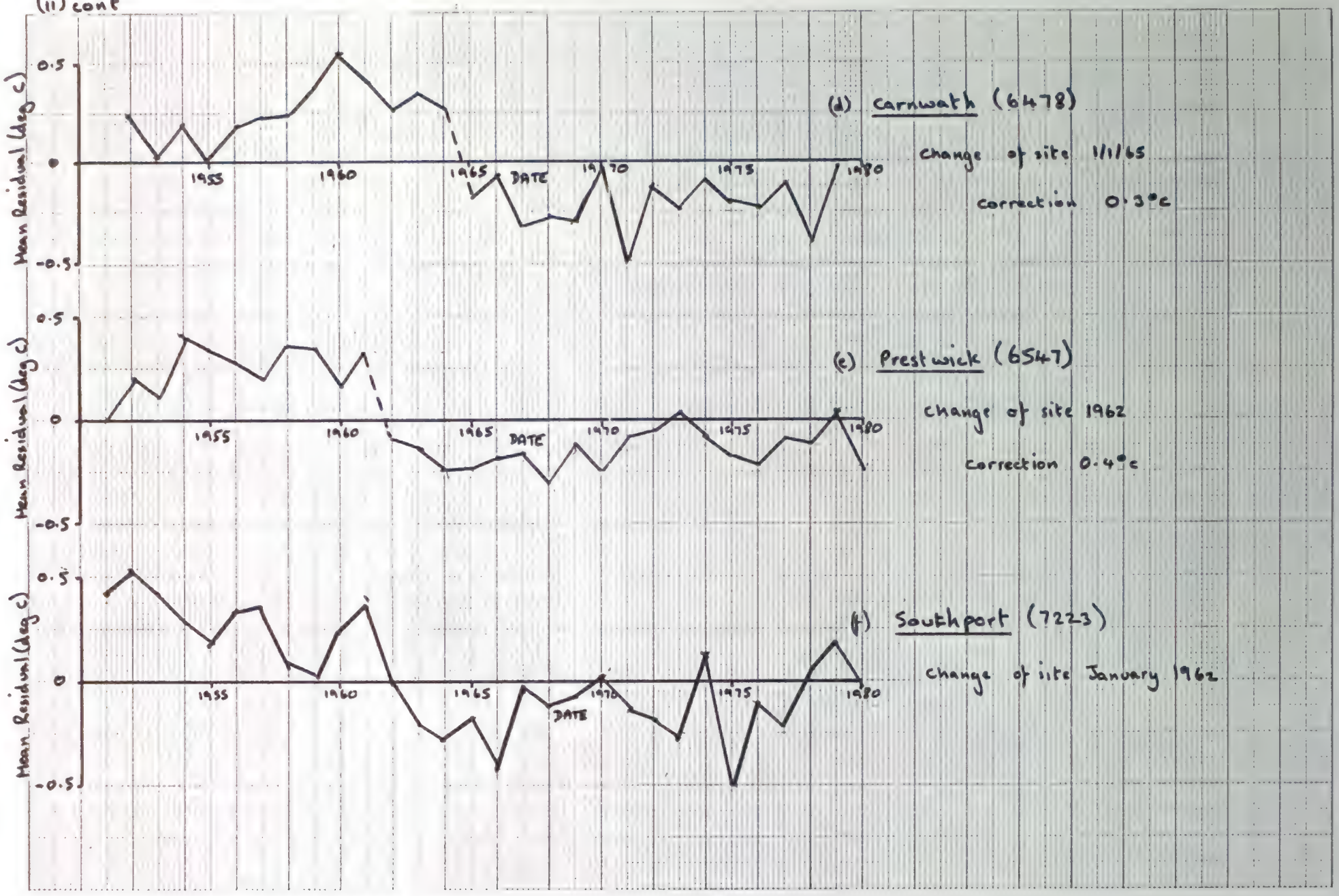
(i) Llety-Evan-Hen (8078)

Fig 1 (cont) Step changes identified with corrections suggested where possible

(ii) Daily minimum temperatures



(ii) cont



(d) Carnwath (6478)

change of site 1/1/65

correction 0.3°c

(e) Prestwick (6547)

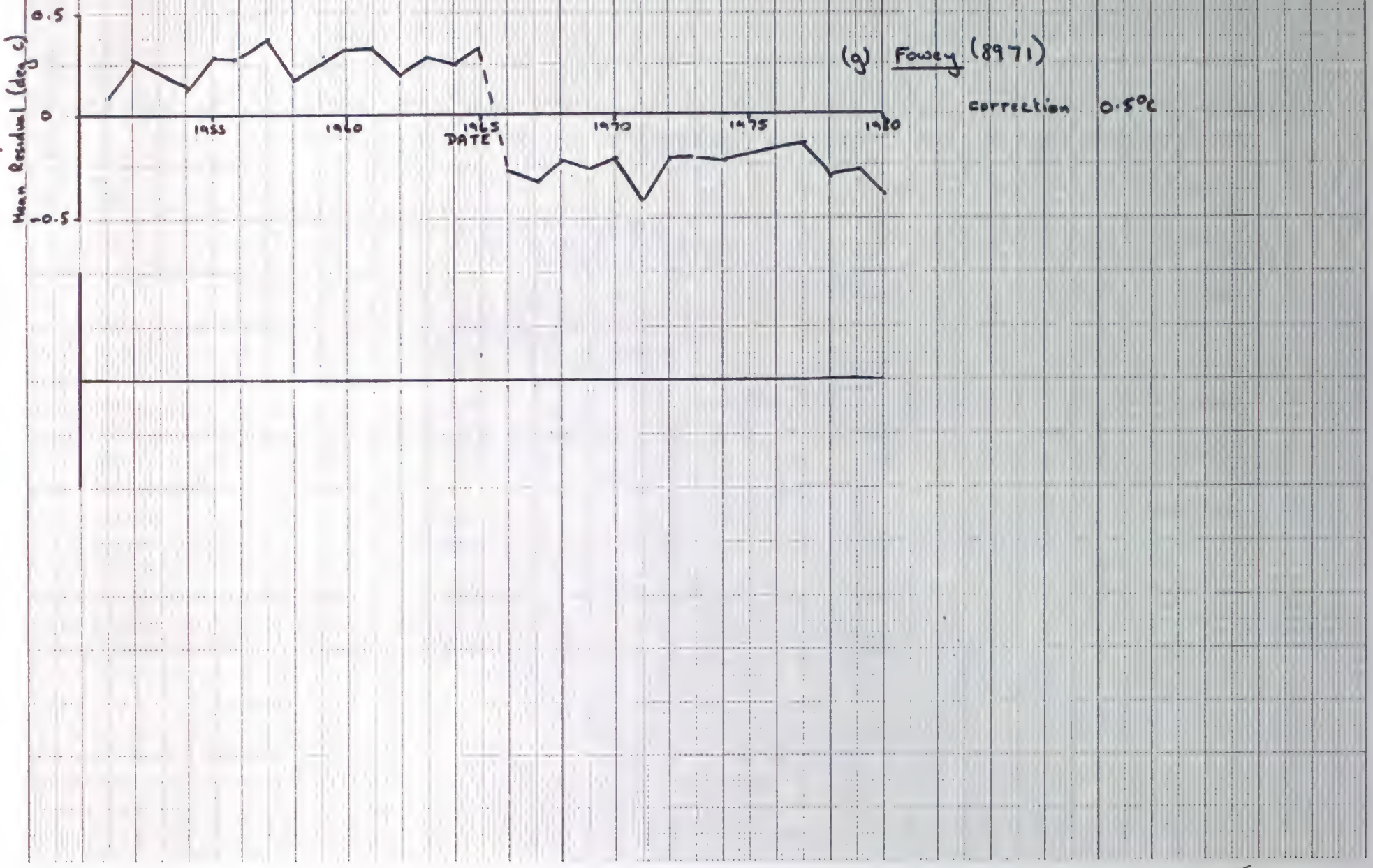
change of site 1962

correction 0.4°c

(f) Southport (7223)

change of site January 1962

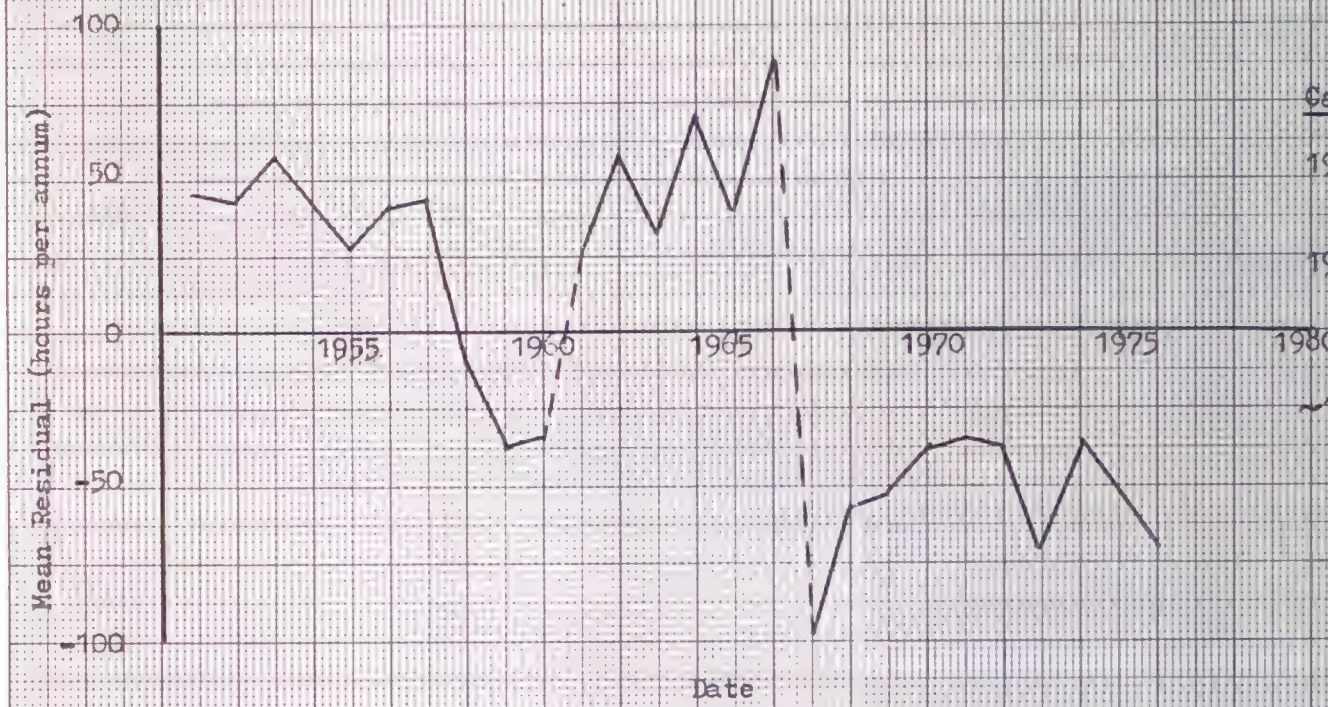
(ii) cont.



(g) Fowey (8971)

correction 0.5°C

Figure 2. Two significant changes of site identified from the residuals of monthly sunshine.



Cardiff (8492)

1960 site moved due to growth of trees.

1967 site moved to Ty Twyn. A poor site obscur ed by trees.

~125-150 hrs per annum difference between the two sites.

Figure 3. Scottish stations thought to have suffered no significant site changes but still flagged by the routine

Fig. 3 cont.

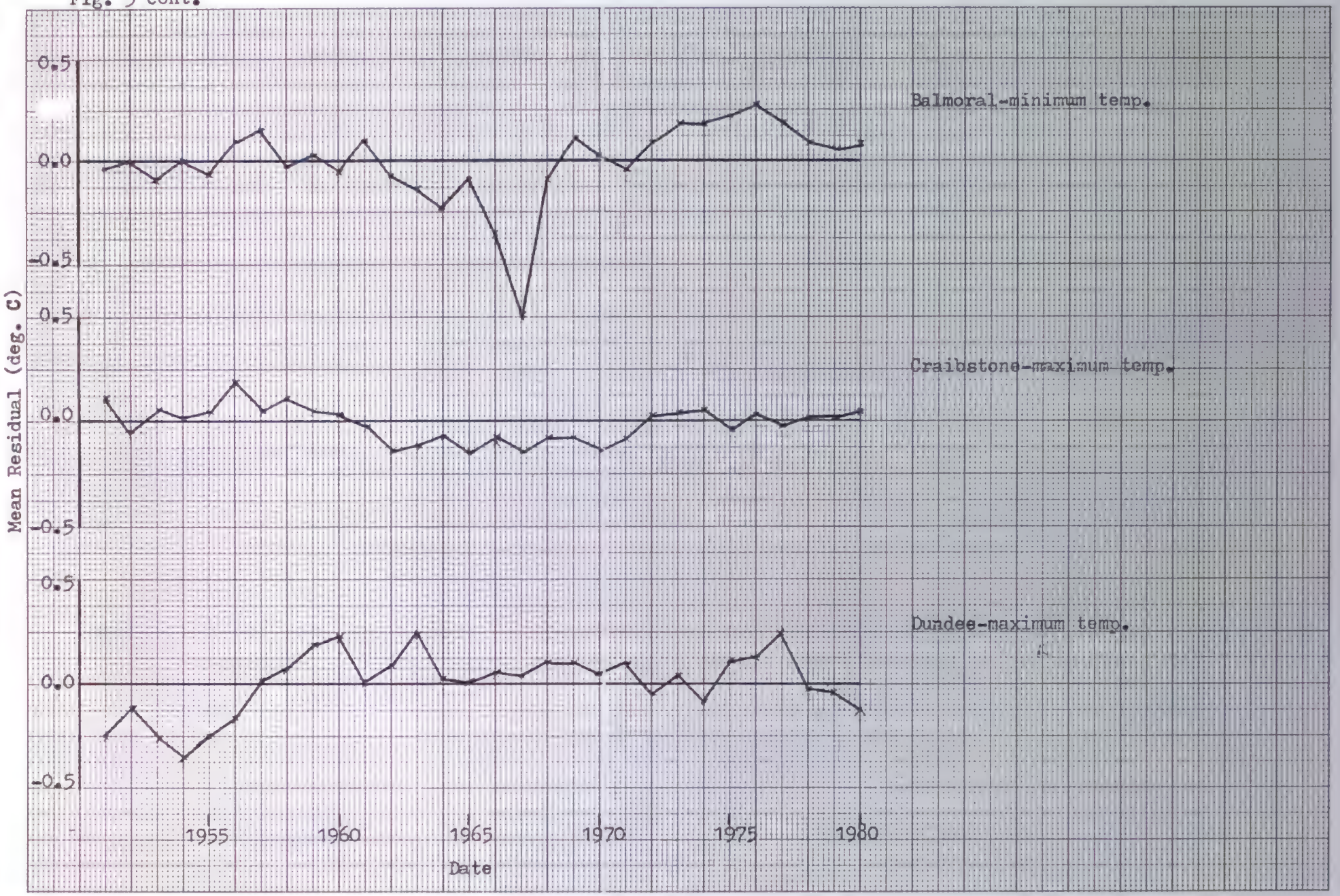

0.5
0.0
-0.5
0.5
0.0
-0.5
0.5
0.0
-0.5
Mean Residual (deg. C)
Balmoral-minimum temp.
Craibstone-maximum temp.
Dundee-maximum temp.
1955
1960
1965
1970
1975
1980
Date

Fig. 3 cont

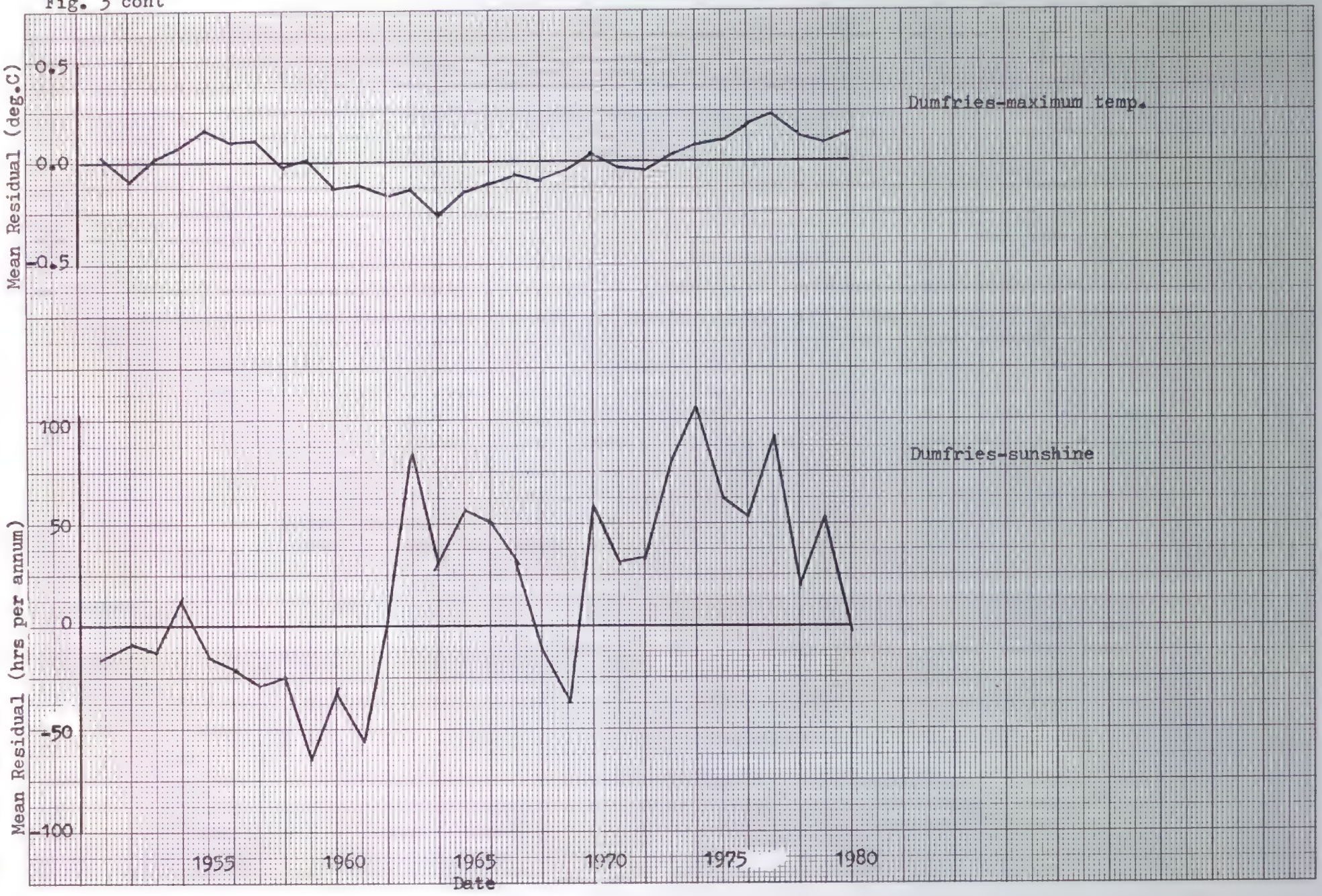

Mean Residual (deg.C)
0.5
0.0
-0.5
Dumfries-maximum temp.
Mean Residual (hrs per annum)
100
50
0
-50
-100
Dumfries-sunshine
1955
1960
1965
1970
1975
1980
Date

Fig.3 cont

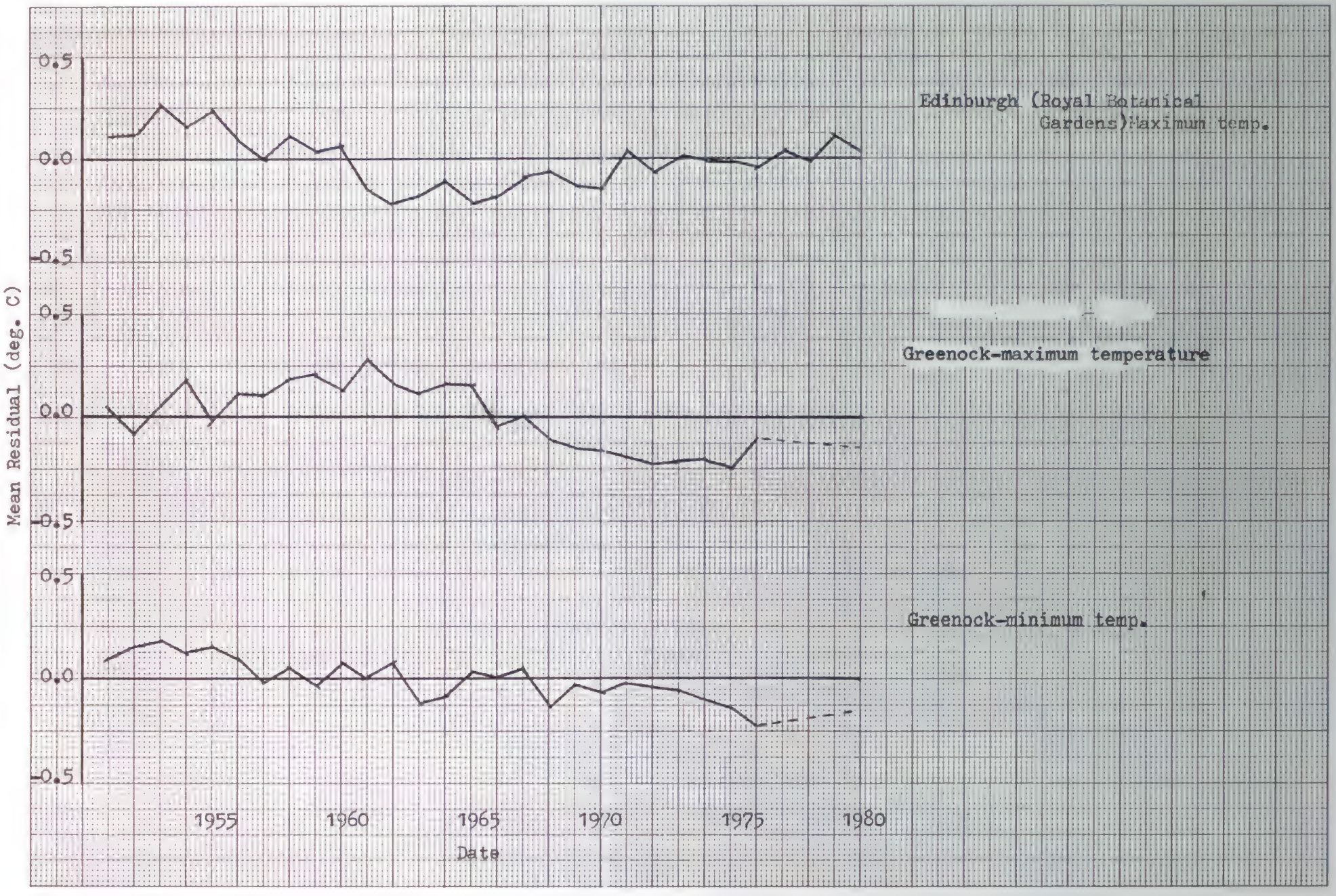

0.5
0.0
-0.5
0.5
0.0
-0.5
0.5
0.0
-0.5
Mean Residual (deg. C)
1955
1960
1965
1970
1975
1980
Date
Edinburgh (Royal Botanical Gardens)-Maximum temp.
Greenock-maximum temperature
Greenock-minimum temp.

Fig.3 cont.

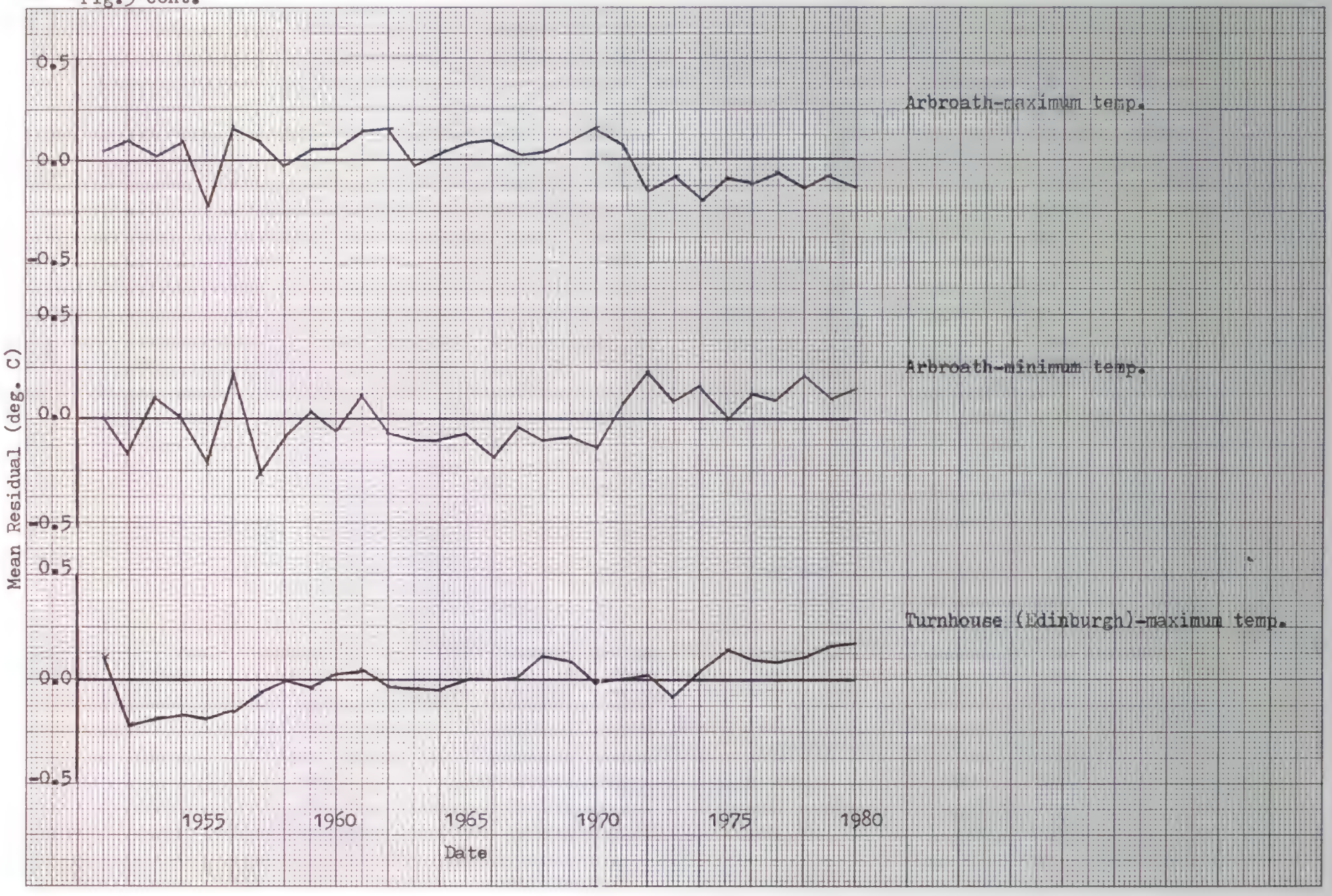

0.5
0.0
-0.5
0.5
0.0
-0.5
0.5
0.0
-0.5
Mean Residual (deg. C)
1955
1960
1965
1970
1975
1980
Date
Arbroath-maximum temp.
Arbroath-minimum temp.
Turnhouse (Edinburgh)-maximum temp.

Figure 4. Inhomogeneities identified in the temperature record for Blackford Hill (Edinburgh), supported by a comparison of the recorded values with a neighbouring station

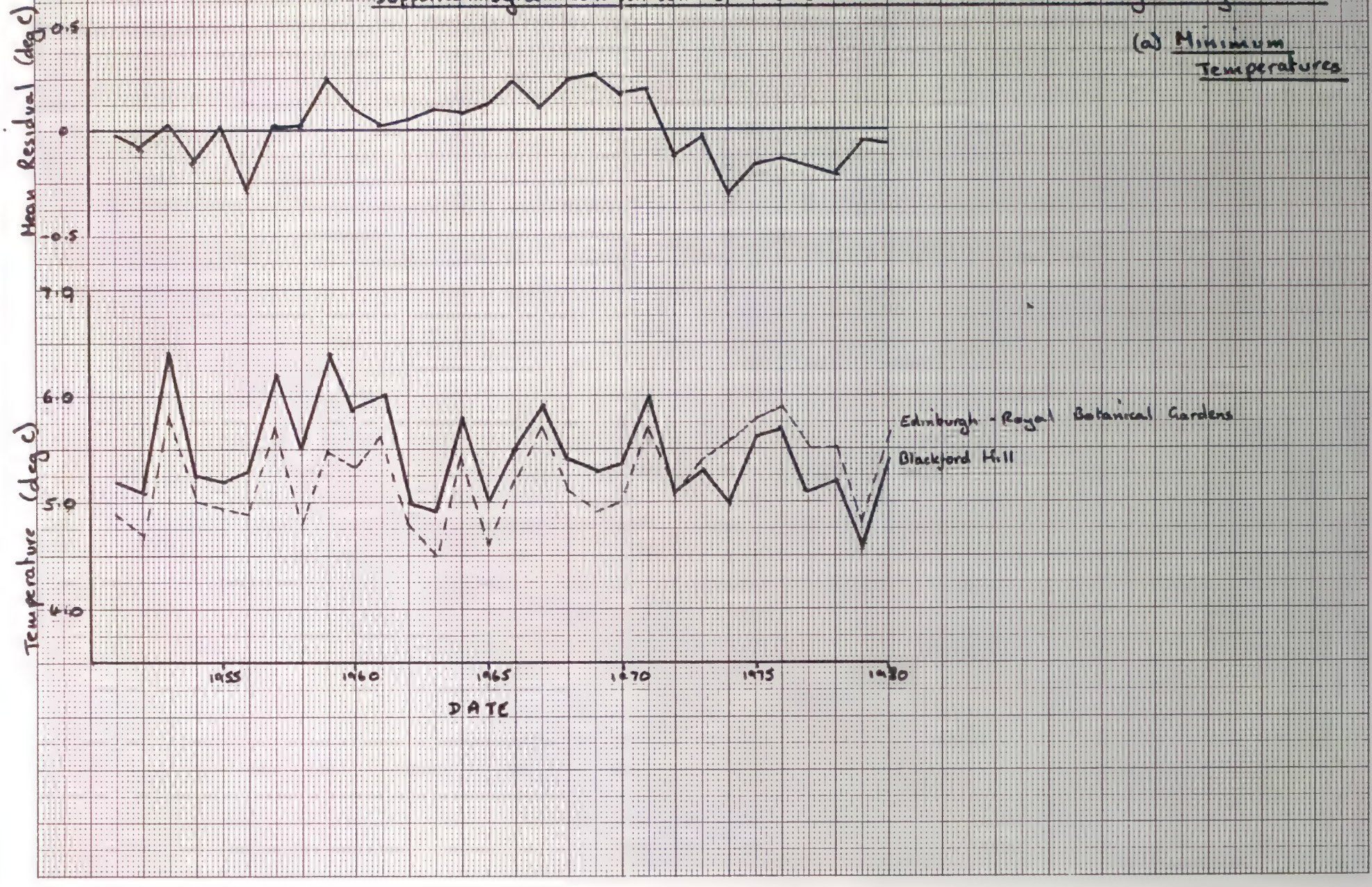


Figure 4 (cont) Inhomogeneities identified in the residuals for Blackford Hill (Edinburgh), supported by a comparison of the recorded values with a neighbouring station

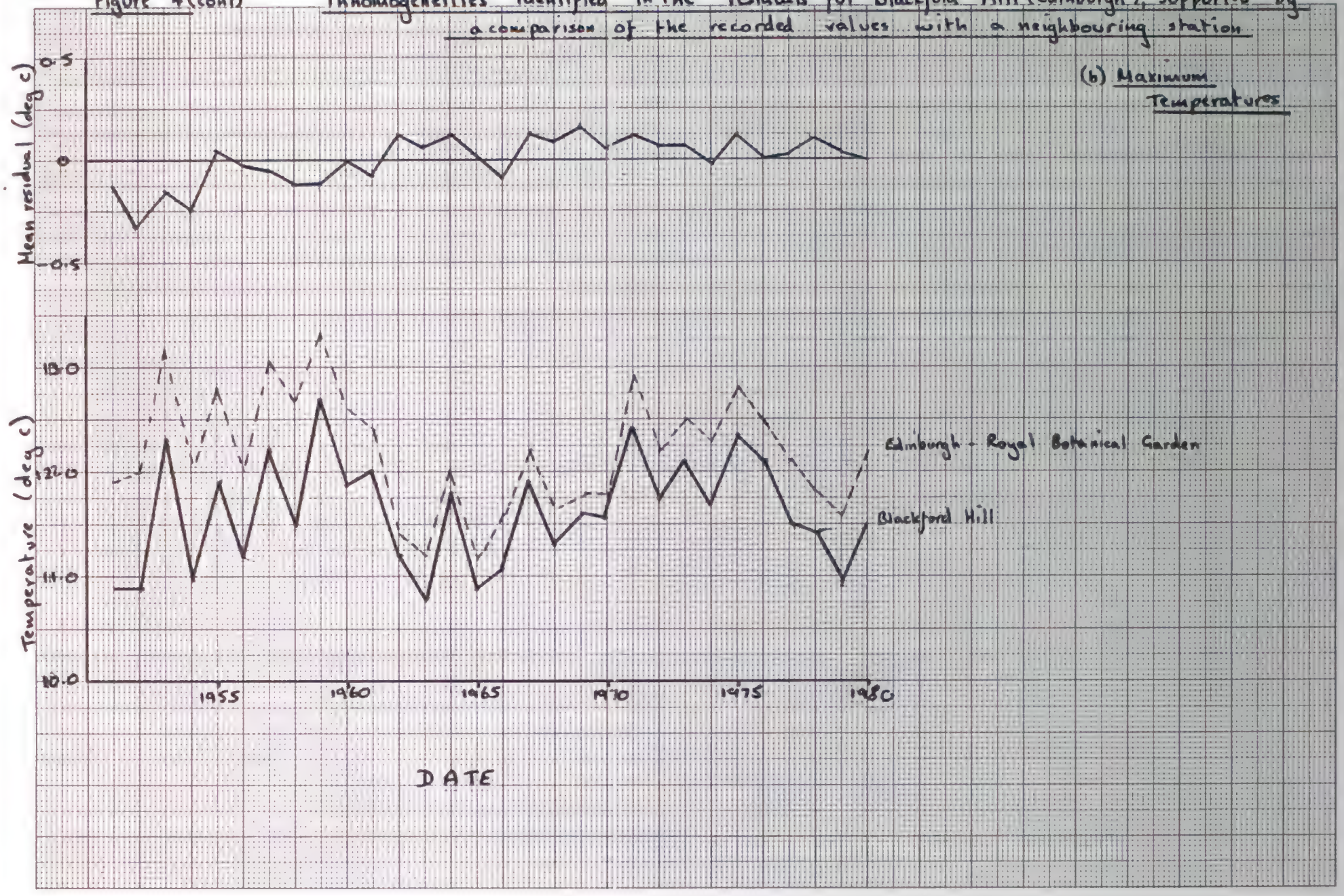


Figure 5. The effect of the growth of trees on a climatological station.

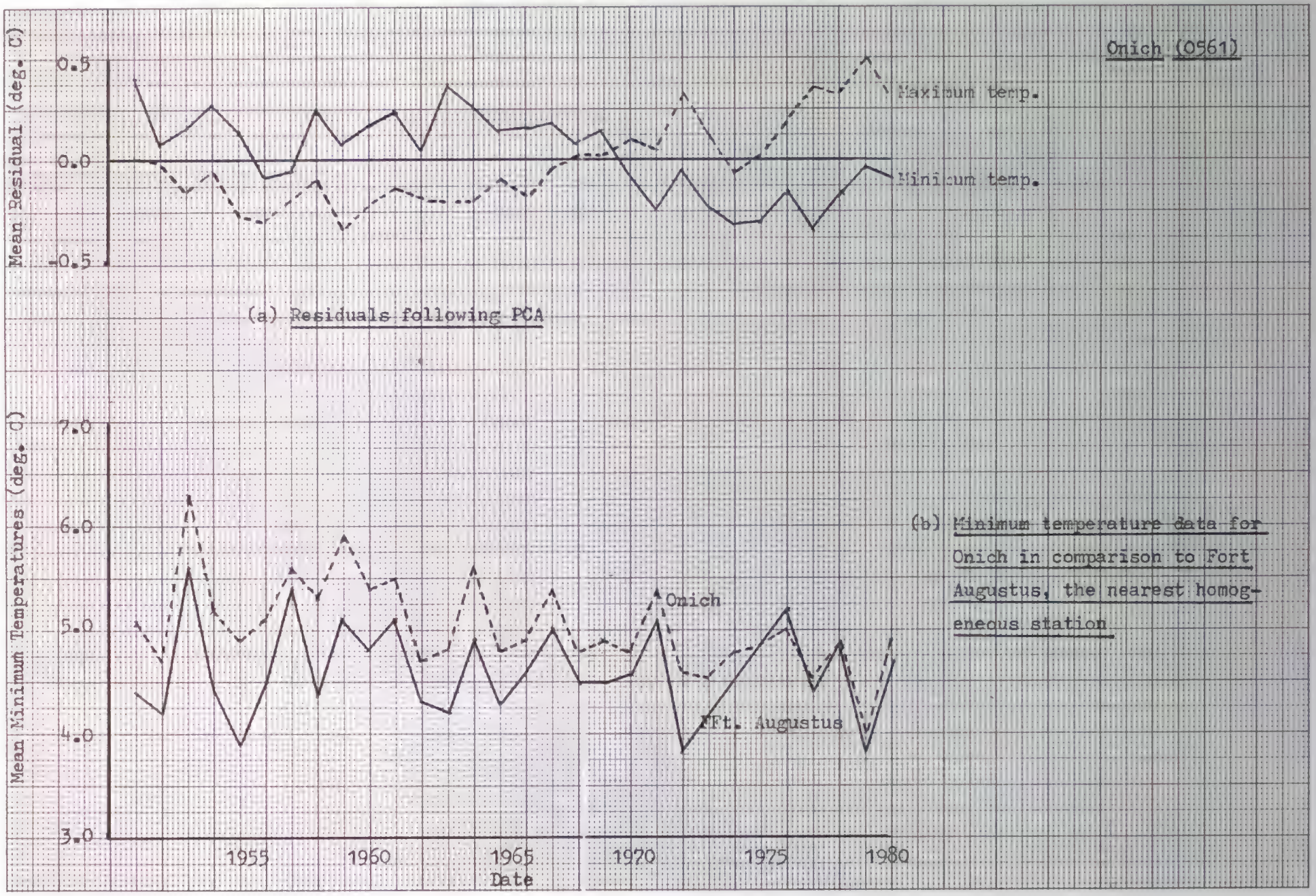


Figure 6. Inhomogeneities identified from the pre-1982 WMO reference stations

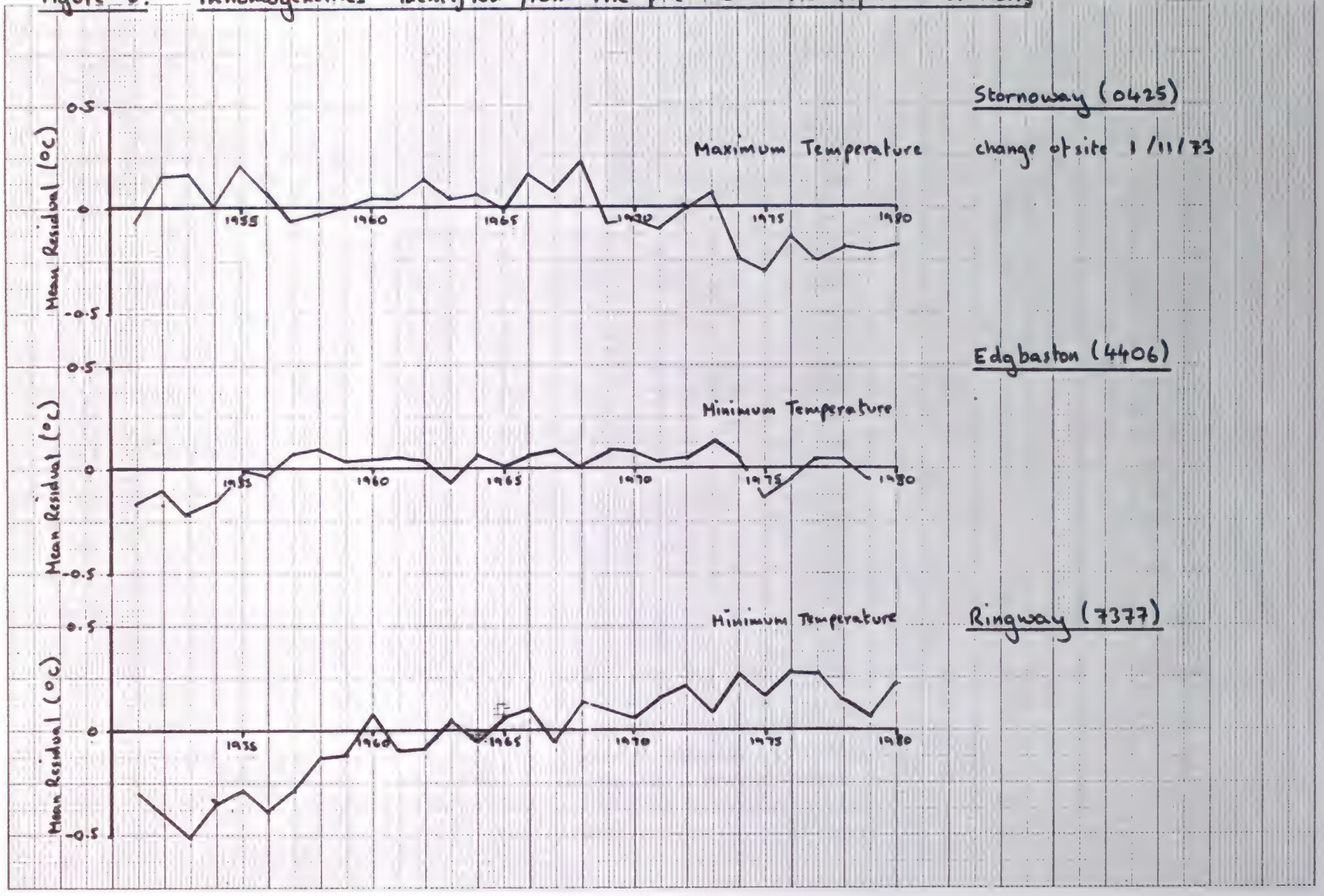


Figure 7. Upward trend in minimum temperatures for Ringway, as identified by the residuals, illustrated by a comparison with a neighbouring station

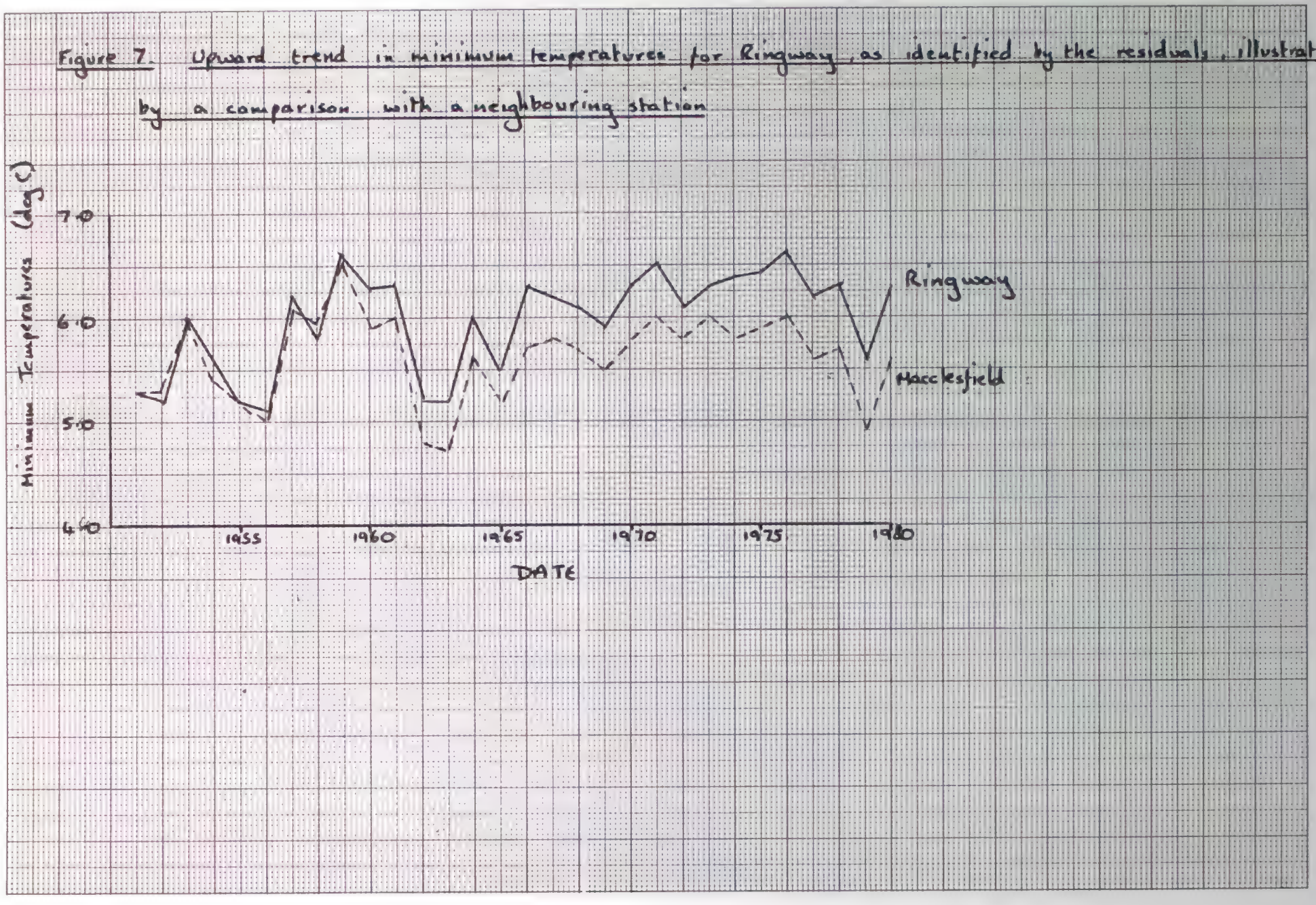
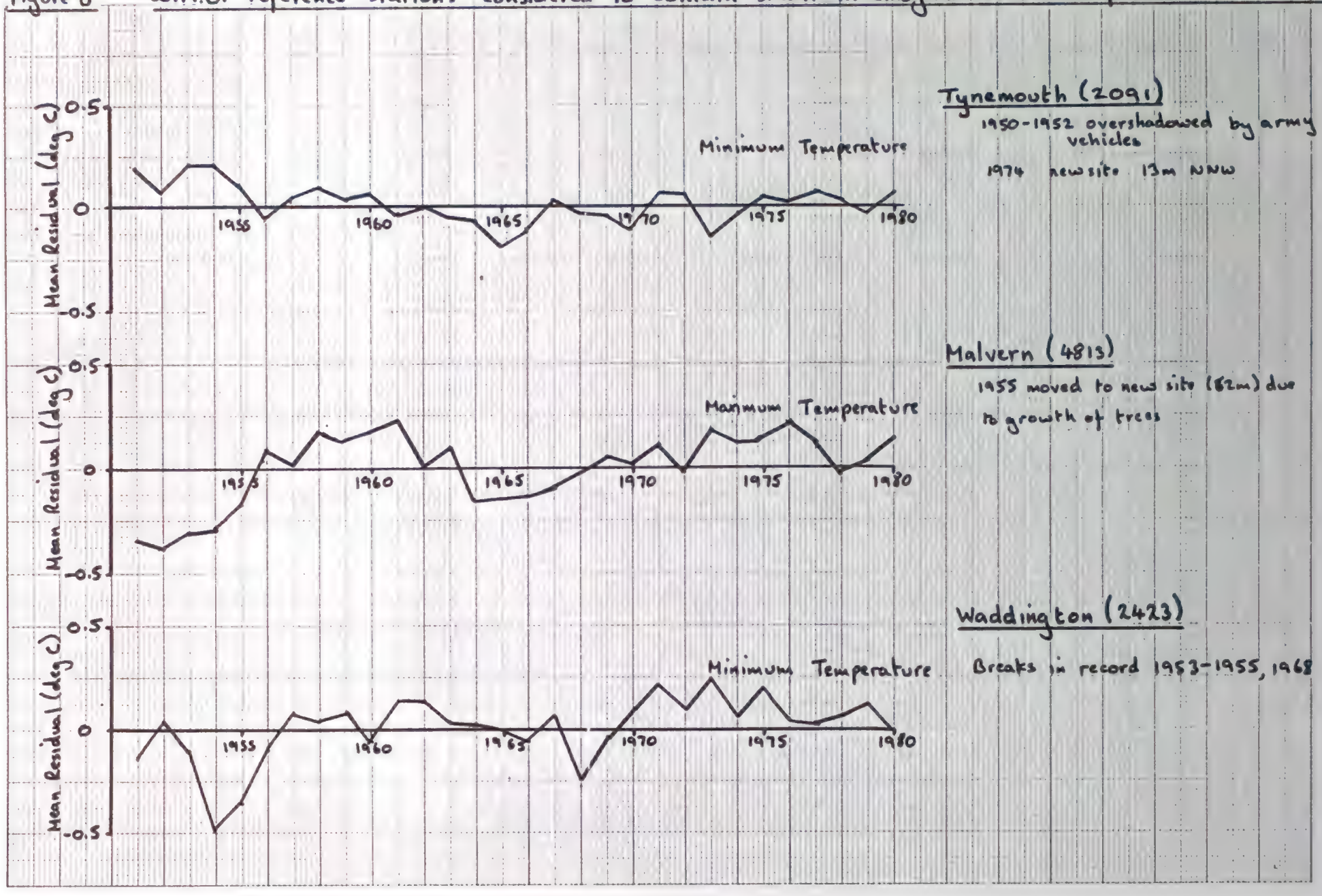


Figure 8 W.M.O. reference stations considered to contain small inhomogenkities in the period 1951-80



Tynemouth (2091)

1950-1952 overshadowed by army vehicles

1974 new site 13m NNW

Malvern (4813)

1955 moved to new site (62m) due to growth of trees

Waddington (2423)

Breaks in record 1953-1955, 1968

Figure 9. Marked inhomogeneity identified by the routine in the Kinloss sunshine record (1960-61)

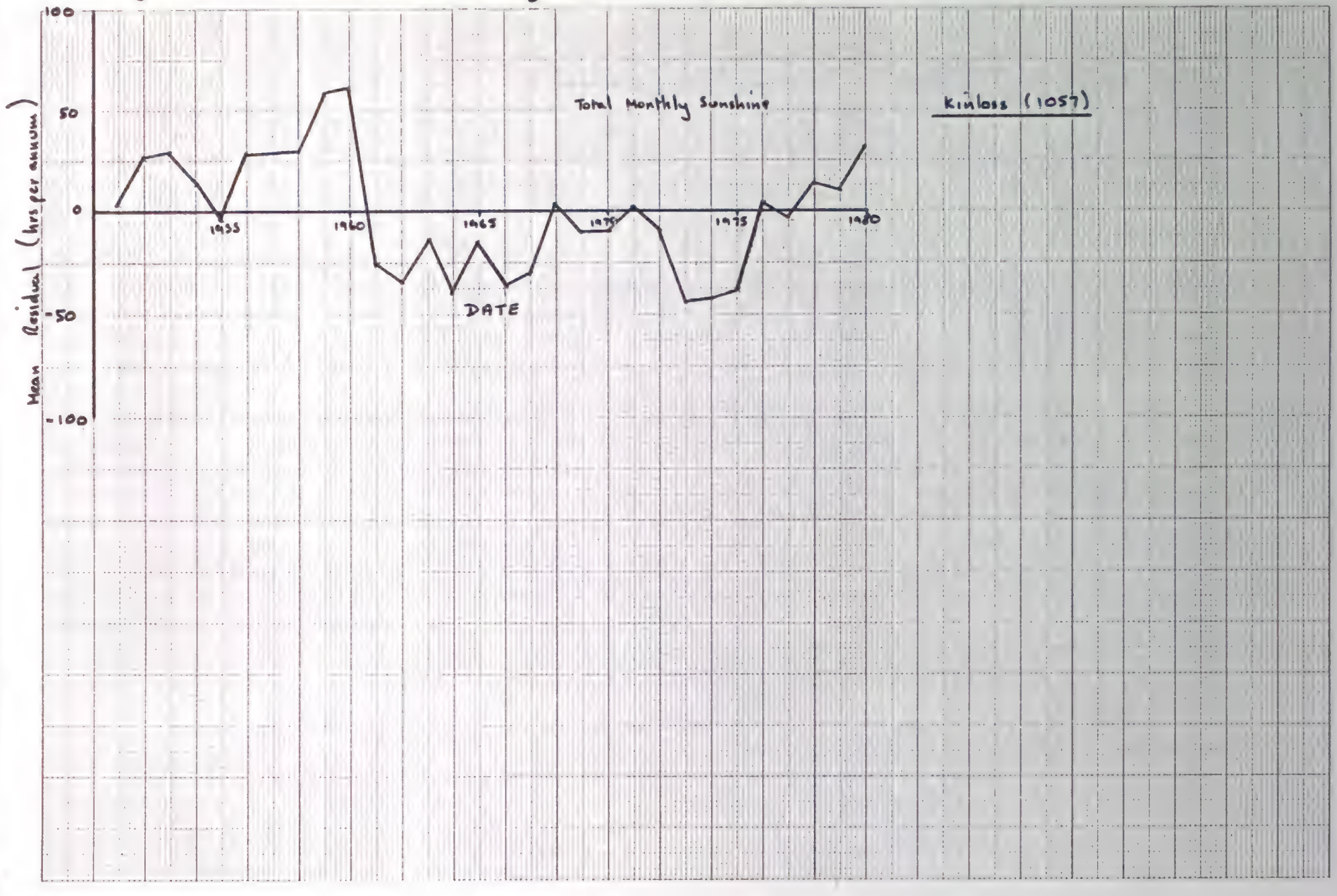


Figure 10 Inhomogeneities identified in the Braemar residuals for 1951-80

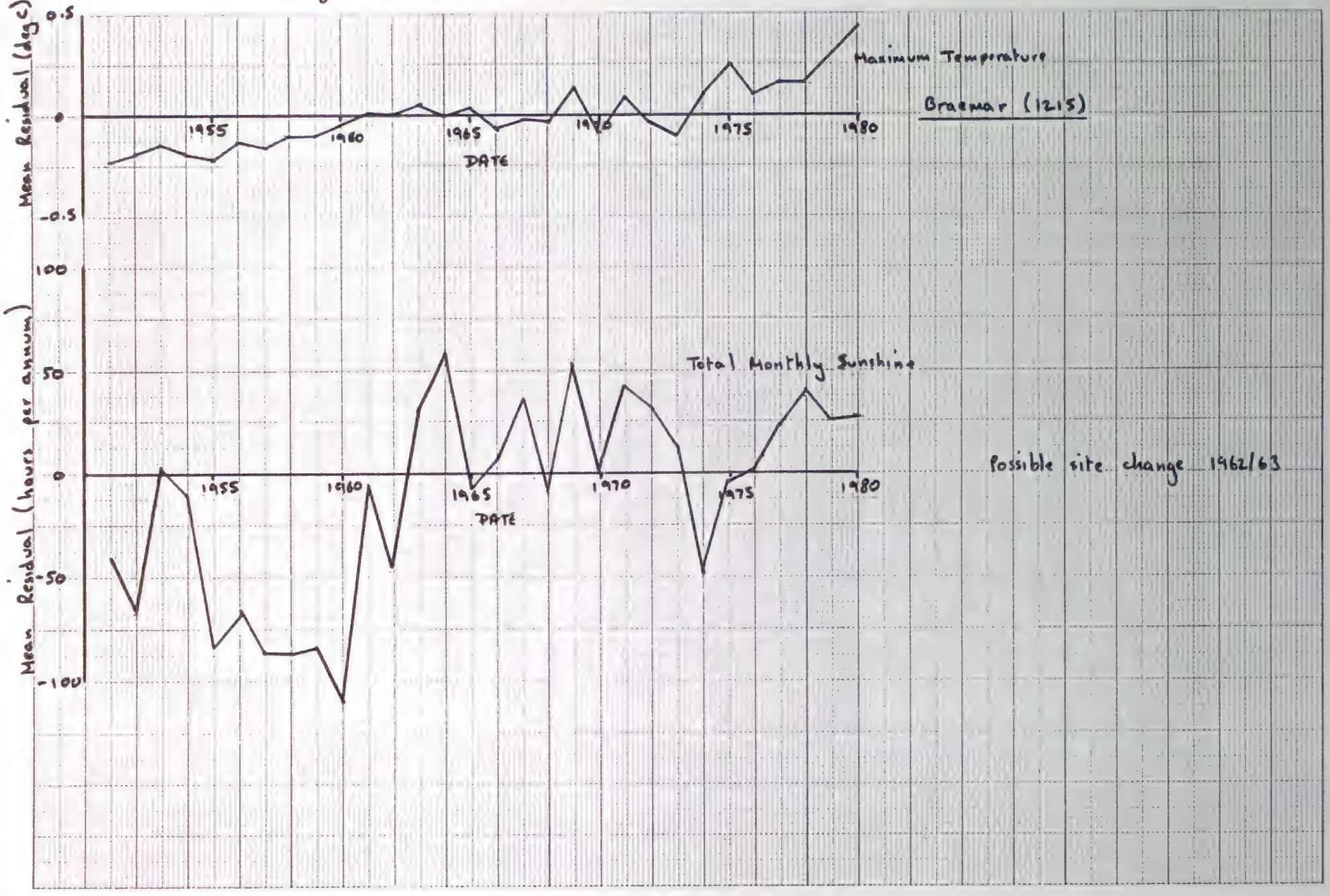
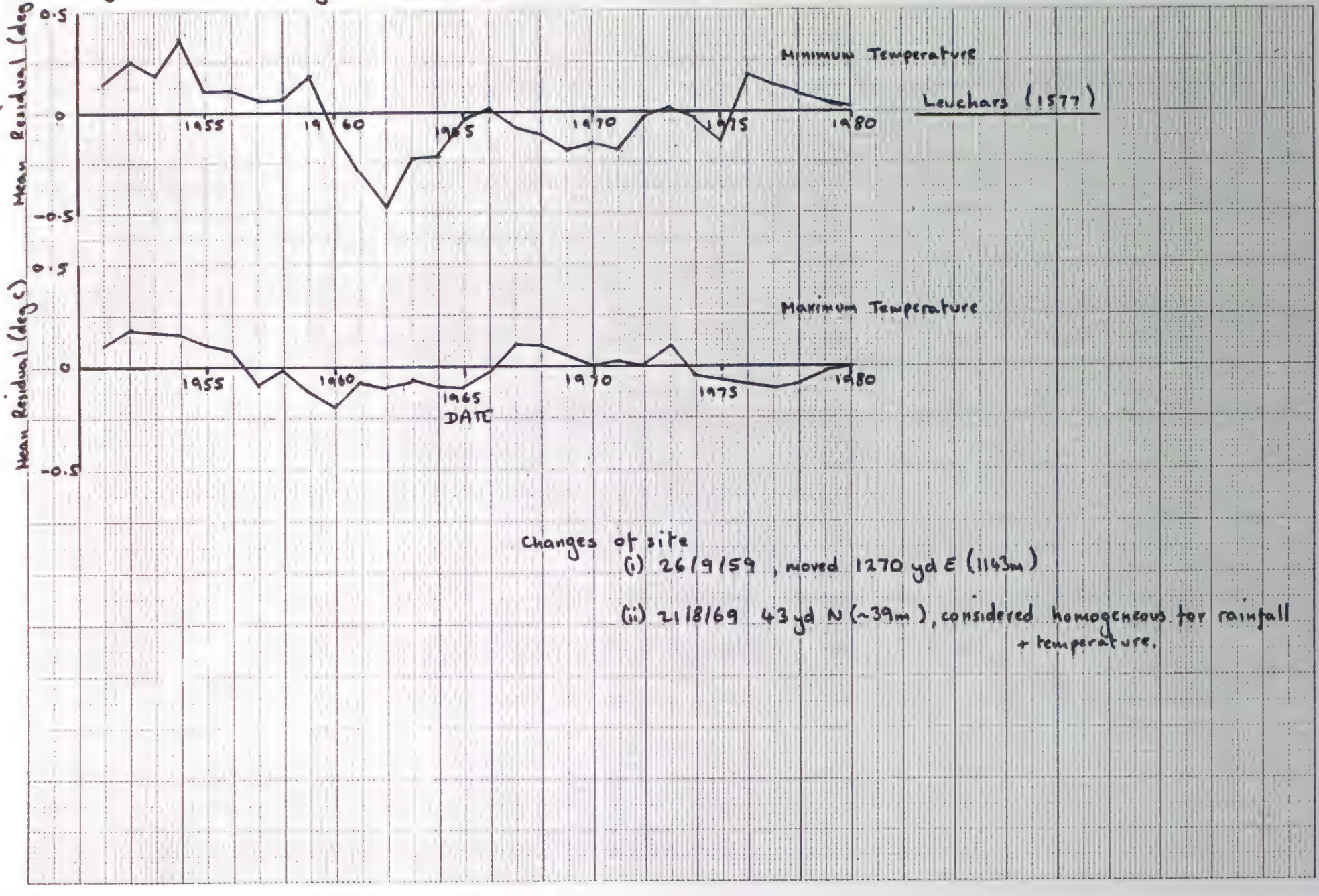


Figure 11 Inhomogeneities identified in the Leuchars residuals 1951-80



Changes of site

(i) 26/9/59, moved 1270 yd E (1143m)

(ii) 21/8/69 43 yd N (~39m), considered homogeneous for rainfall + temperature.

Figure 12 Inhomogeneities identified in the Auchincruive residuals 1951-80

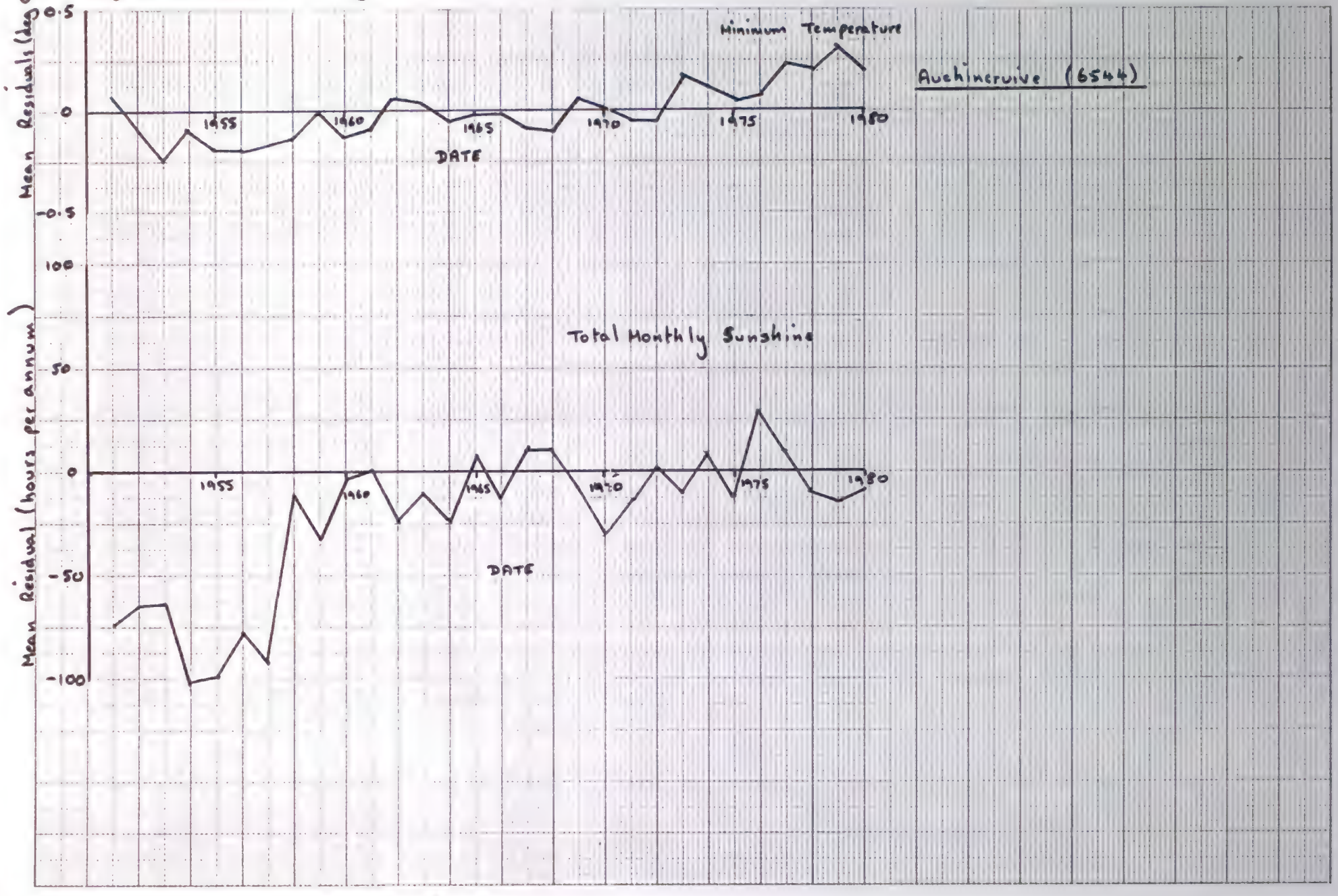


Figure 13 Inhomogeneities identified in the Valley residuals 1951-80

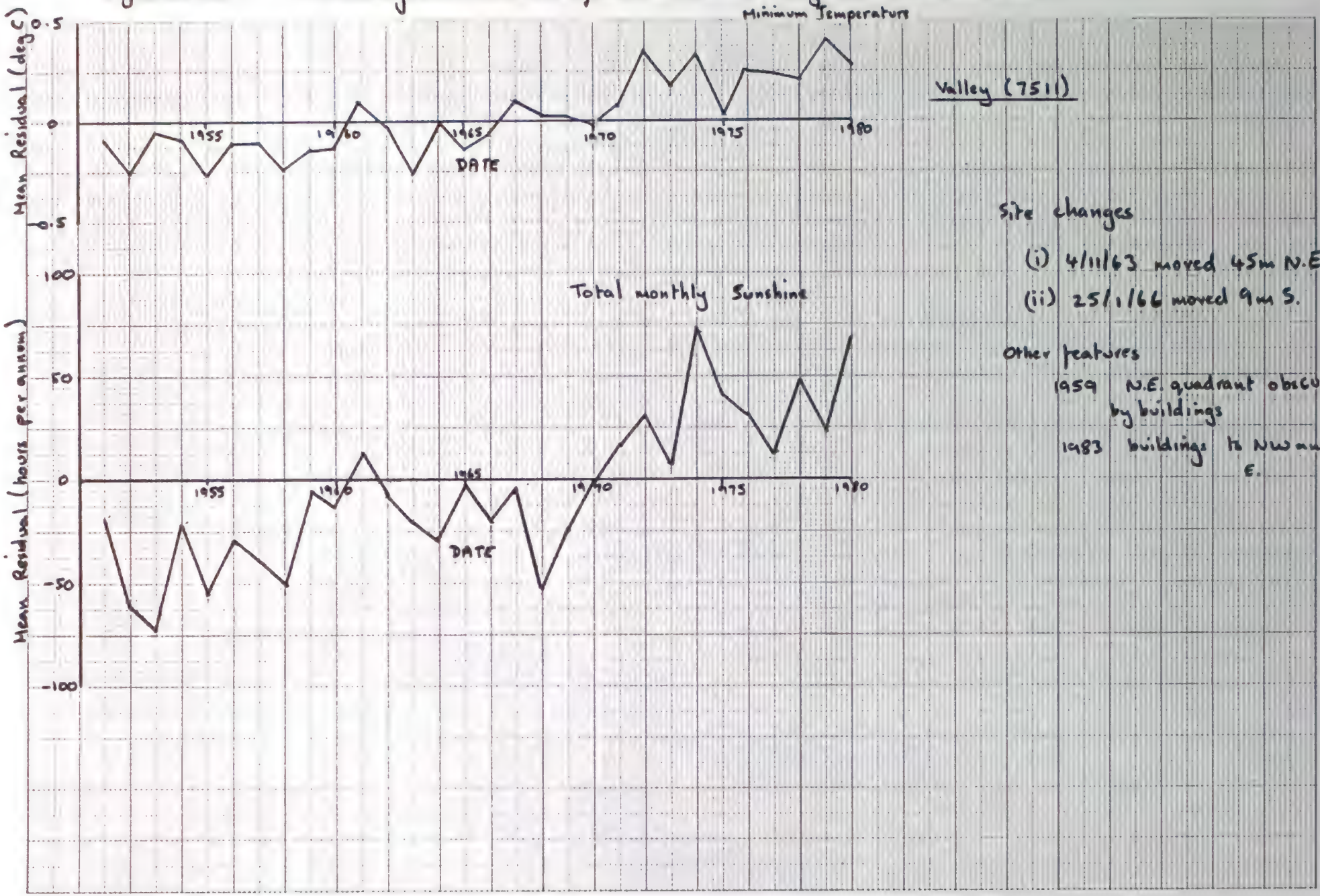


Figure 14 Inhomogeneities identified in the Armagh residuals 1951-80

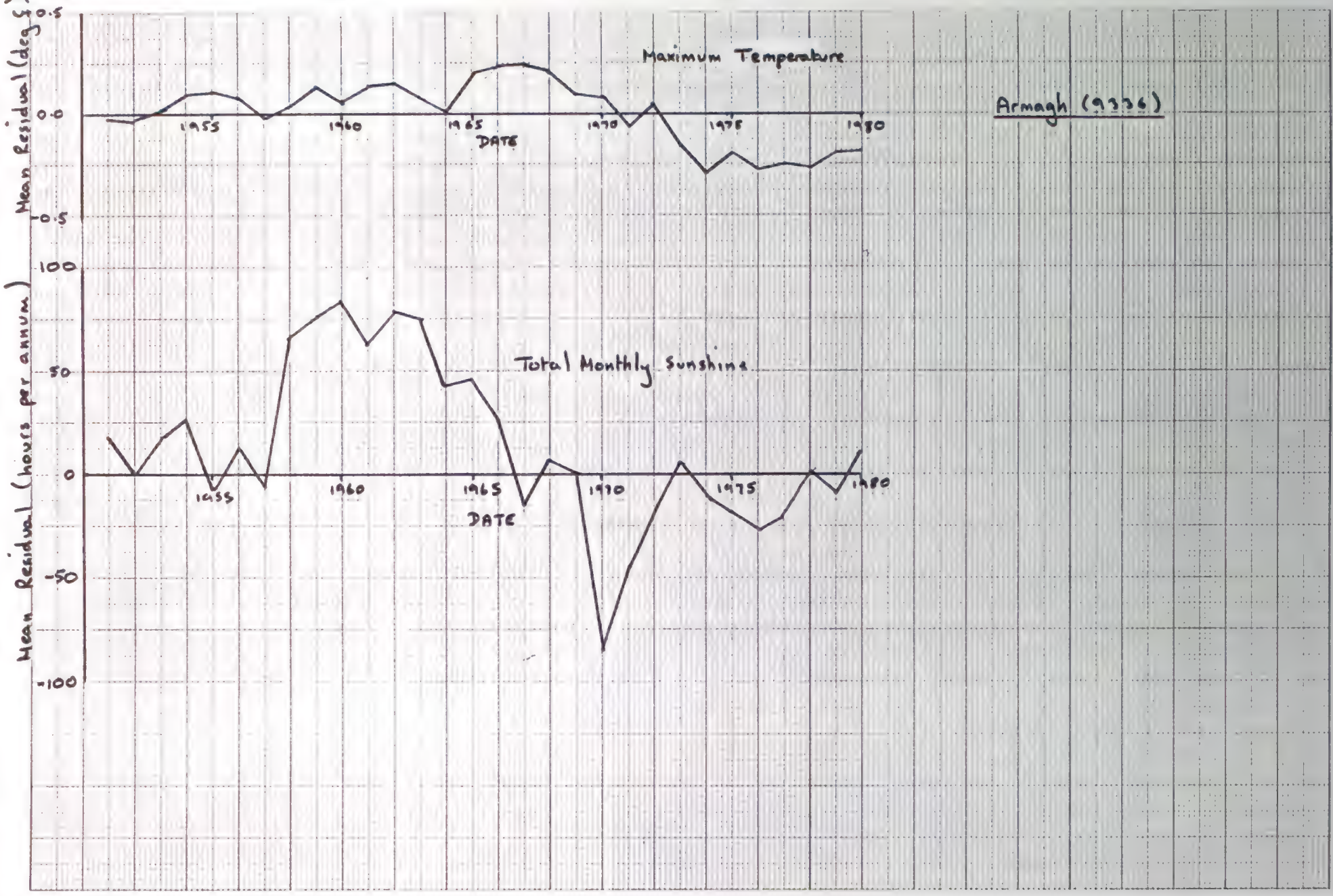
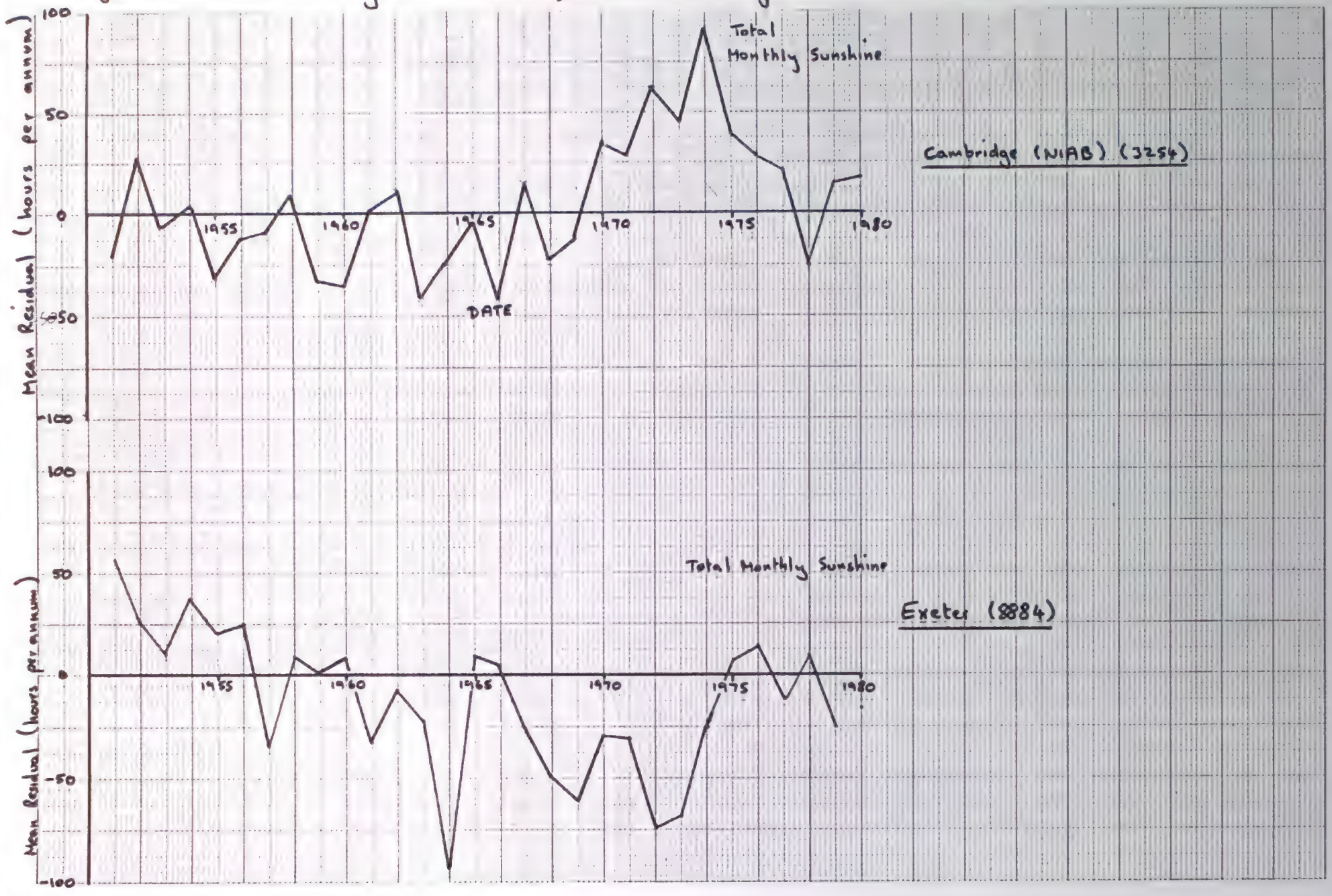


Figure 15 Inhomogeneities identified at Cambridge (NIAB) and Exeter



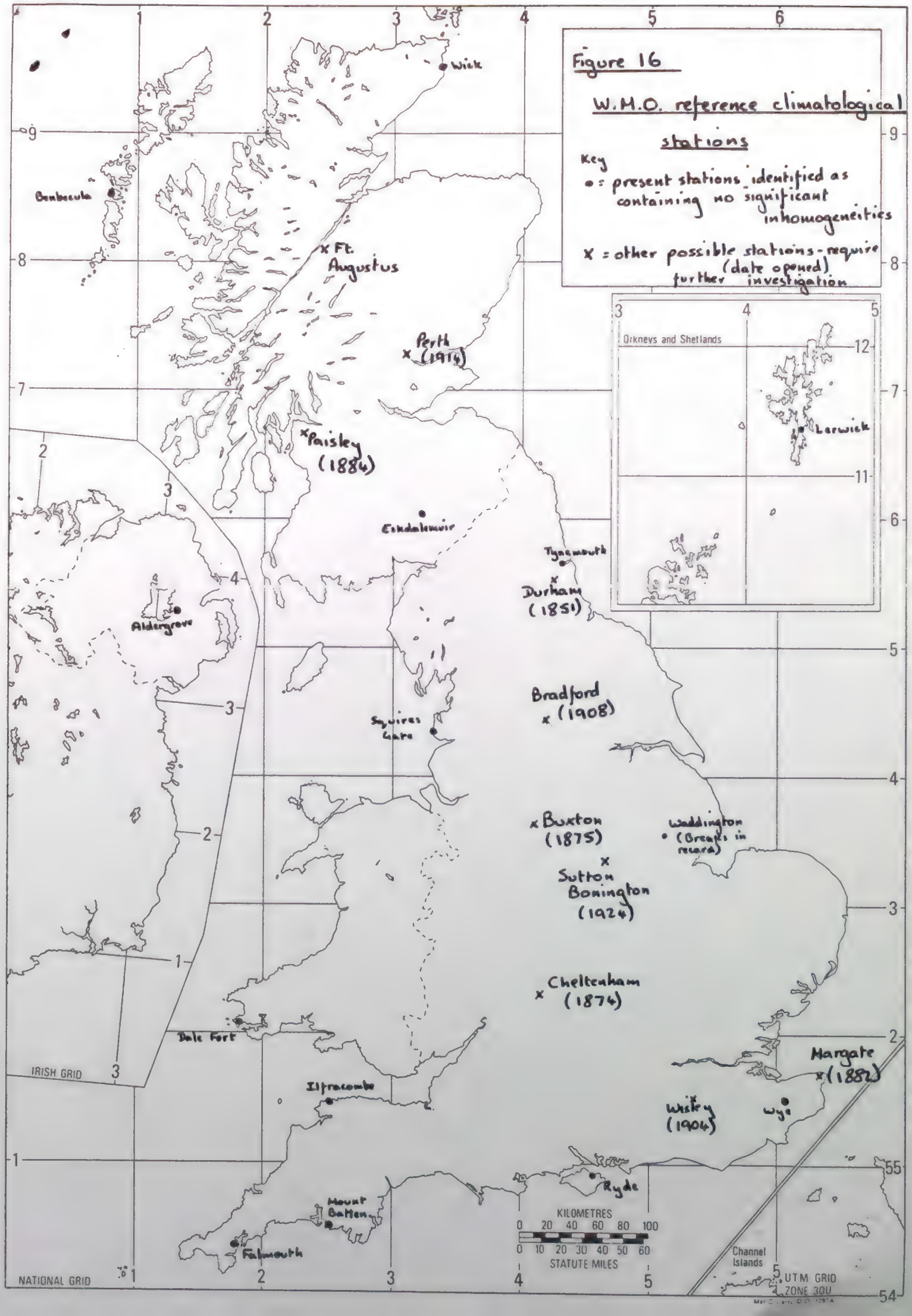


Figure 16
W.M.O. reference climatological stations
Key
• = present stations identified as containing no significant inhomogeneities
× = other possible stations - require further investigation (date opened)
Orkneys and Shetlands
Lerwick
Wick
Benbecula
× Ft. Augustus
× Perth (1914)
× Paisley (1884)
Eskdalemuir
Tynemouth
× Durham (1851)
Aldergrove
Bradford × (1908)
Squires Gate
× Buxton (1875)
Waddington • (Breaks in record)
× Sutton Bonington (1924)
× Cheltenham (1874)
Dale Fort
Margate × (1882)
Ilfracombe
Wisley (1904)
Wye
Ryde
Mount Batten
Falmouth
Channel Islands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
UTM GRID ZONE 30U

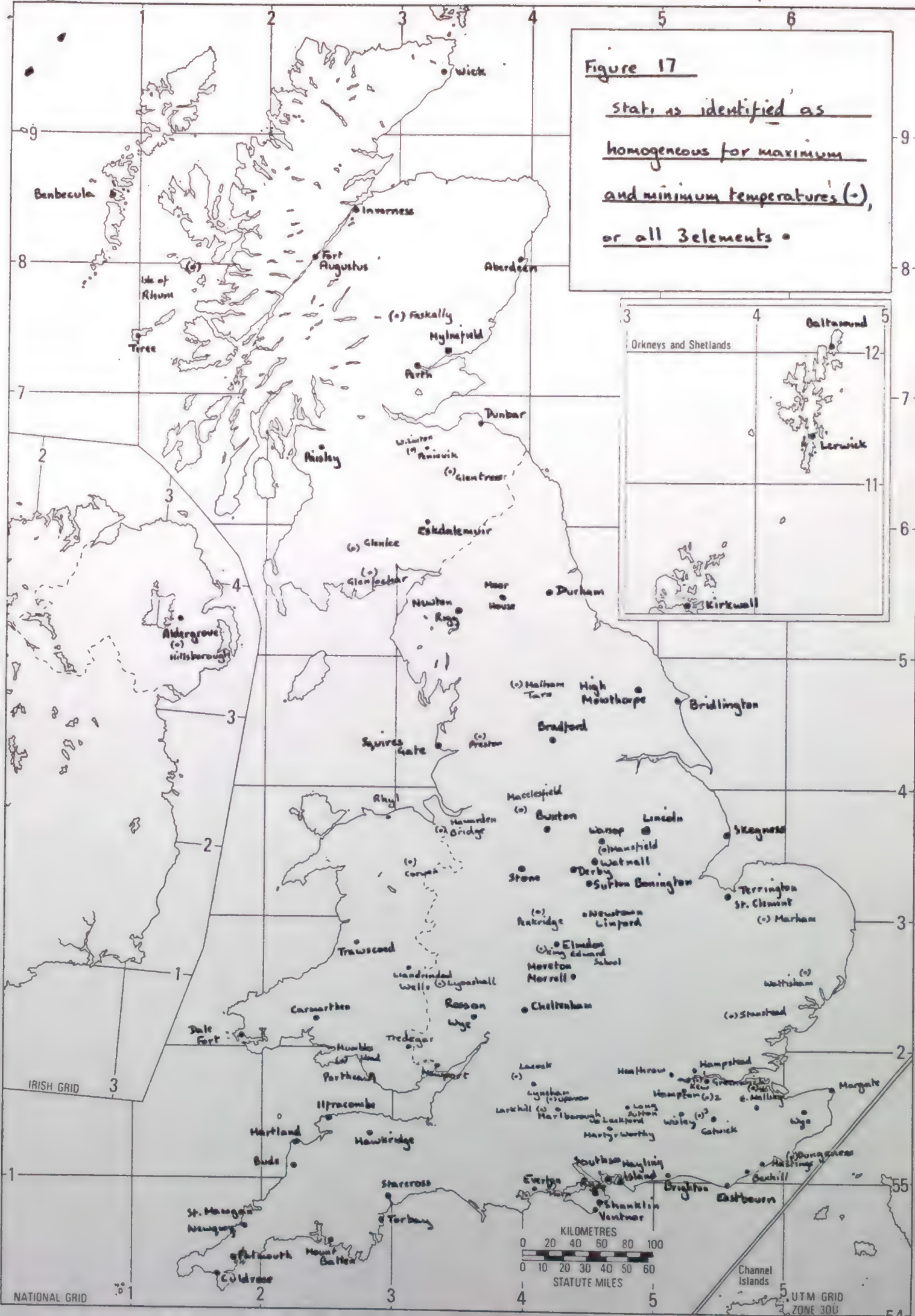


Figure 17
Stations identified as homogeneous for maximum and minimum temperatures (•), or all 3 elements •
Wick
Benbecula
Inverness
Fort Augustus
Aberdeen
Isle of Rhum
Tiree
(•) Faskally
Mylnefield
Perth
Dunbar
Paisley
Glentress
Eskdalemuir
Glenlee
Glenlochar
Moor House
Durham
Newton Rigg
Aldergrove
Hillsborough
Malham Tarn
High Mowthorpe
Bridlington
Bradford
Squires Gate
Preston
Rhyl
Macclesfield
Buxton
Lincoln
Hawarden Bridge
Warsop
Skegness
Mansfield
Watnall
Corwen
Stone
Derby
Sutton Bonington
Terrington St. Clement
Penkridge
Newtown Linford
Marham
Trawscoed
Elmdon
King Edward School
Moreton Morrell
Llandrindod Wells
Lyonshall
Wattisham
Carmarthen
Rosson Wye
Cheltenham
Stanstead
Dale Fort
Tredegar
Humbles Head
Portheawl
Newport
Lacock
Henthrow
Hampstead
Greenwich
Margate
Lyneham
Upavon
Hampton
Larkhill
Marlborough
Long Sutton
Lockford
Wisley
Gatwick
Wye
Ilfracombe
Hartland
Hawkridge
Martyr Worthy
Bude
Southsea
Hayling Island
Dungeness
Hastings
Bexhill
Everton
Brighton
Eastbourn
Starcross
Shanklin
Ventnor
St. Mawgan
Newquay
Torbay
Falmouth
Mount Batten
Culdrose
Orkneys and Shetlands
Baltasound
Lerwick
Kirkwall
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
UTM GRID ZONE 30U

To be added to Met O 3 Technical Note No 32

F.A. Crummay (Jan 1986)

A method for monitoring the homogeneity of climatological records as discussed in the main body of this technical note, was performed for all U.K. climatological stations in the 1951-80 dataset. The following appendices contain a list of all such stations with the results of the study detailed in Appendix A and diagrams of the residuals for each flagged station in Appendix B.

Originally only stations with 15-30 years data were tested for homogeneity. This has been expanded to include those with 10-15 years data, leading to 577 stations present for the temperature variables and 391 for sunshine. The homogeneity of each station record is tested by calculating the residuals between the 'actual' annual mean values and the 'expected' values obtained by the performing of a Principal Component Analysis (PCA) for each of ten districts. These residuals were divided into two groups, for example:

(i) first 5 years, last 25 years

(ii) first 10 years, last 20 years

with the means of the two subsets compared using a T-test. A new clause has been added to ensure that at least two years data are present in each of the subsets. This latter will reduce the dependence on a single years data which may result in the erroneous flagging of a station. As a result the number of sunshine stations flagged was reduced to 36 with 114 flagged for maximum temperature and 123 for minimum temperature.

Statistical significance testing is a relative rather than an absolute process, and as such must not be taken as providing a definitive decision. Several points can be raised, for example:-

(i) The T-test process used will be heavily dependent on the amount of data available, 0.01°C can become significant with a long enough record. The testing routine will therefore preferentially 'pass' stations with a short record of observations.

(ii) The testing routine is more likely to identify inhomogeneities in the middle of a climatic record than those at the end.

(iii) Stations with a poor standard of observations throughout the 30 year period are likely to be passed by the testing routine in contrast to a

station with a gentle change in a climatic variable which may be flagged. One specific example of the latter is evident in the Cromer record for maximum temperature (Appendix B). Here the variation in residual over the 30 year period is less than 0.15°C, of no practical significance, yet it has been flagged as statistically significant.

To identify such 'practical' inhomogeneities a further test was necessary and took the form of an inspection of each of the residual graphs provided in Appendix B with a view to identifying some absolute level of practical significance. Such a level has been suggested as ± 0.2°C for the temperature variables and ± 50 hours per annum for sunshine. These can easily be checked visually from the graphs and the stations identified by this process are distinguished in the listing of the climatological stations (Appendix A) as described below.

Key to the list of climatological stations (Appendix A)

√	station homogeneous with respect to the element indicated
-	insufficient data for the station to be tested for homogeneity
*	insufficient data to allow inclusion in a P.C.A.
x	station flagged as inhomogeneous with respect to the element indicated.
(x)	stations flagged as inhomogeneous but with an absolute level of inhomogeneity less than ± 0.2°C (temperature) or ± 50 hours per annum (sunshine).

Appendix C provides a revised documentation for program QD HOMO (Technical Note No 32 Appendix 1)

Appendix A

Results of testing UK climatological stations in the 1951-80 datasets.

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
0032	Hamnavoe	1962-1972	√	√	/
0043	Lerwick (Psych)	1971-1980	√	√	/
0044	Lerwick (S.Screen)	1952-1980	√	√	/
0088	Baltasound	1953-1980	√	x	√
0104	Sule Skerry	1957-1973	√	/	-
0144	Stenness	1961-1974	√	√	√
0154	Kirkwall	1951-1980*1	√	√	√
0208	Dounreay	1959-1980*2	√	√	√
0293	Wick	1952-1980*3	√	/	√
0329	Cape Wrath	1951-1980*4	√	x	√
0351	Achany	1959-1970*5	√	√	-
0352	Lairg	1971-1980*6	√	√	-
0388	Strathy	1959-1976	√	√	√
0425	Stornoway	1952-1980	x	x	√
0430	Balmacara House	1963-1978	√	√	-
0434	Poolewe	1963-1980	√	√	√
0435	Rudh Re	1966-1977	√	√	-
0437	Inverpolly	1963-1980*7	√	√	-
0443	Achnashellach	1951-1980	√	√	-
0445	Kinlochewe	1959-1978	x	√	√
0454	Strathconon	1968-1980	√	√	-
0482	Fortrose	1951-1980	x	x	√
0499	Tarbatness	1968-1980	√	√	-
0516	Benbecula	1951-1980*8	√	√	√
0533	Isle of Rhum	1959-1980	√	√	-
0537	Prabost	1959-1980	√	x	√
0561	Onich	1951-1980	x	x	√
0566	Corpach	1967-1980	√	√	-
0575	Fort Augustus	1952-1980	√	√	/
0584	Lagganlia	1971-1980	√	√	-
0588	Inverness	1959-1980	√	√	/
0595	Achnagoichan	1960-1970, 1974	√	√	-
0596	Glenmore Lodge	1959-1980*9	*	*	/
1008	Nairn	1951-1980	x	x	√
1042	Grantown-on Spey	1966-1980*10	√	/	√

*1 Sunshine = 1957-1980; *2 Sunshine = 1968-1979; *3 Sunshine = 1966-1980;

*4 Sunshine = 1964-1980; *5 Sunshine = 1965-1970; *6 Sunshine = 1971-1975;

*7 Sunshine record 1964-1975, Large number of gaps; *8 Sunshine 1957-1980;

*9 Missing data still present for temperature variables; *10 Sunshine 1970-1980.

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
1048	Forres	1959-1976	✓	✓	(x)
1057	Kinloss	1951-1980	✓	✓	x
1078	Elgin	1966-1980*1	✓	✓	✓
1079	Lossiemouth	1959-1980	✓	✓	-
1095	Gordon Castle	1951-1971	x	✓	✓
1115	Glenlivet	1957-1980*2	x	x	✓
1189	Banff	1960-1980	x	✓	✓
1215	Braemar	1951-1980	x	✓	x
1226	Balmoral	1951-1980	✓	✓	-
1242	Dinnet	1962-1980*3	✓	✓	✓
1256	Gartly	1968-1980	✓	✓	-
1264	Inverurie	1967-1980*4	✓	✓	✓
1267	Fyvie Castle	1959-1980*5	✓	✓	✓
1272	Craibstone	1951-1980	(x)	✓	✓
1273	Dyce	1951-1980	x	✓	✓
1280	Aberdeen	1951-1980*6	✓	✓	✓
1289	Fraserburgh	1967-1979*7	✓	✓	✓
1297	Rattray Head	1957-1968	✓	✓	✓
1303	Fettercairn	1959-1973	✓	✓	✓
1317	Strachan	1962-1971*8	✓	✓	-
1318	Banchory	1967-1980*9	✓	✓	-
1324	Stonehaven	1959-1980*10	✓	✓	✓
1351	Mylnefield	1959-1980	(x)	x	✓
1361	Dundee	1951-1980	x	✓	✓
1366	Glamis Castle	1959-1973	✓	✓	-
1379	Whitehillocks	1962-1980	✓	x	-
1380	Buddon Ness	1959-1973	✓	✓	-
1382	Carnoustie	1959-1973,'77	✓	✓	✓
1393	Arbroath	1951-1980	x	x	✓
1397	Usan	1965-1979	✓	✓	✓
1398	Montrose	1959-1980	x	✓	-
1417	Dall, Rannoch School	1961-1980*11	✓	x	-
1434	Callander	1968-1980	✓	✓	-
1435	Ardtalnaig	1959-1980*12	✓	✓	-
1444	Drummond Castle	1970-1980	✓	✓	✓
1462	Gleneagles	1964-1976	✓	✓	✓
1467	Faskally	1959-1980	✓	✓	-
1481	Strathallan School	1968-1980	✓	✓	-
1482	Perth	1951-1979	x	x	✓

*1 Sunshine = 1966-1976, 1978; *2 No Data 1962, 1962-63 (Sunshine); *3 Sunshine = 1964-1980; *4 No Data 1973; *5 Sunshine = 1959-1972, No Data 1965-66; *6 Sunshine = 1951-1977 Gap in record Oct. 1972-Sept 1974; *8 Sunshine = 1963-1971; *9 Sunshine = 1973-1978; *10 Large gaps in record; *11 No Data 1965-66, 1968.

*12 Sunshine = 1971-1980

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
1485	Blairgowrie	1960-1976	✓	✓	✓
1516	Kinross	1968-1980	✓	✓	✓
1531	Pitreavie	1961-1980	✓	✓	-
1551	Kirkcaldy	1959-1975	✓	✓	✓
1566	Cupar(Sugar Factory)	1959-1972*1	✓	✓	-
1577	Leuchars	1951-1980	(x)	x	✓
1588	St Andrews	1959-1980	✓	x	✓
1603	Livingstone	1969-1980	✓	✓	-
1634	Turnhouse	1951-1980	x	✓	✓
1636	Edinburgh-East Craigs	1959-1980*2	x	x	x
1638	Davidson's Mains	1959-1970	✓	✓	✓
1641	Penicuik	1959-1980	✓	✓	✓
1643	Bush House	1959-1980	✓	✓	✓
1646	Edinburgh-Blackford Hill	1951-1980	x	x	✓
1649	Edinburgh-Royal Botanic Gardens	1951-1980	x	✓	x
1675	Haddington	1959-1980*3	✓	x	✓
1699	Dunbar	1951-1980	✓	✓	✓
1726	Lauder	1960-1971	✓	✓	✓
1744	Marchmount	1951-1980	x	✓	✓
1747	Whitchester	1962-1980	x	✓	-
1789	St Abbs Head	1957-1980	x	✓	-
1823	Stanhope Farm	1959-1980	x	✓	-
1836	Blyth Bridge	1959-1980	*	*	✓
1838	West Linton	1959-1980	✓	✓	-
1866	Glentrees	1959-1980	✓	✓	-
1935	Bowhill	1959-1980	✓	✓	-
1939	Galashiels	1967-1980	✓	✓	✓
1963	Wauchope	1959-1976	x	✓	-
1989	Kelso	1966-1980*4	✓	✓	-
1993	Sourhope	1959-1973	✓	✓	✓
2007	Kielder Castle	1951-1980	✓	x	-
2027	Redesdale	1970-1980	✓	✓	✓
2034	Haydon Bridge	1955-1980	✓	x	-
2042	Corbridge	1961-1971	✓	✓	-
2058	Berwick-On-Tweed	1959-1974	✓	✓	✓
2084	Cockle Park	1952-1980	✓	x	✓
2086	Acklington	1957-1975	✓	✓	✓
2091	Tynemouth	1952-1980	✓	x	✓

*1 Sunshine = 1967-1972; *2 Sunshine = 1961-1980; *3 Sunshine = 1959-1977;

*4 Sunshine = 1966-1973.

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
2098	Seahouses	1963-1979	✓	✓	✓
2138	Chopwellwood	1951-1980*1	x	x	-
2155	Ushaw College	1959-1971	✓	✓	-
2163	Houghall	1961-1976*2	✓	✓	✓
2165	Durham	1952-1980	✓	✓	✓
2181	Hartburn Grange	1969-1980	✓	✓	✓
2194	Hartlepool	1951-1980*3	✓	✓	✓
2245	Leeming	1965-1980	✓	✓	✓
2260	York Heslington	1964-1980	✓	✓	✓
2264	Appleforth	1951-1971	✓	✓	✓
2269	Redcar	1959-1970	✓	✓	✓
2273	Pickering	1962-1980	✓	✓	-
2289	Whitby	*4	✓	✓	✓
2292	Scarborough	1952-1971	✓	✓	✓
2295	Silpho Moor	1951-1980*5	x	(x)	✓
2299	Whitby Coastguard	1961-1980	✓	✓	-
2337	High Mowthorpe	1951-1980	x	✓	x
2361	Hull	1951-1980	x	✓	x
2364	Leconfield	1959-1969	✓	✓	✓
2378	Filey	1959-1971	✓	✓	✓
2387	Bridlington	1953-1979	✓	✓	x
2391	Kilnsea	1957-1976	✓	✓	✓
2423	Waddington	1951-1980	✓	x	✓
2425	Lincoln	1951-1980*6	✓	✓	✓
2432	Cranwell	1952-1980	✓	x	✓
2438	Brigg	1964-1977	✓	✓	-
2448	Caistor	1965-1980*7	✓	✓	-
2468	Binbrook	1963-1980*8	✓	x	-
2478	Cleethorpes	1951-1980	✓	✓	x
2482	Sutton Bridge	1965-1979	✓	✓	-
2487	Manby	1952-1974	x	✓	✓
2494	Skegness	1951-1980	✓	✓	✓
3007	Terrington St Clement	1951-1980	✓	✓	✓
3024	Marham	1951-'66, 1969-'80*9	✓	✓	-
3031	Santon Downham	1958-1980	(x)	✓	✓
3037	West Raynham	1951-1969	x	x	✓
3055	East Dereham	1965-1976	✓	✓	-
3063	Morley St Botolph	1968-1980	✓	✓	✓

*1 Sunshine 1951-1956; *2 Sunshine = 1961-1970, Some in 1972, 1973; *3 Sunshine = 1955-1980;

*4 Period of record = 1951-1968, 1977-1980; *5 Sunshine = 1961-73, 1977-80;

*6 Sunshine = 1952-1980; *7 Gap in record May '68-Oct'71; *8 Sunshine = 1971-1980;

*9 Sunshine = 1973-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
3069	Cromer	1951-1980	(x)	✓	x
3075	Sprowston	1959-1968	✓	✓	✓
3078	Coltishall	1962-1980	✓	✓	-
3084	Burlingham	1951-1972, 1975	✓	x	✓
3093	Gorleston	1952-1980	x	✓	✓
3107	Mildenhall	1951-1969	✓	✓	✓
3115	Brooms Barn	1964-1980	✓	✓	✓
3127	Honington	1969-1980*1	✓	✓	-
3141	East Bergholt	1953-1980	✓	x	-
3144	Wattisham	1959-1980*2	✓	✓	✓
3193	Aldeburgh	1966-1978*3	-	-	✓
3197	Lowestoft	1951-1980	x	✓	✓
3234	Boxworth(Home Paddock)	1959-1976	(x)	✓	✓
3245	Mepal	1967-1980	✓	✓	✓
3253	Cambridge (Botanic Gardens)	1952-1980	✓	✓	-
3254	Cambridge (NIAB)	1951-1980	✓	✓	x
3357	Monks Wood	1963-1980*4	✓	x	✓
3374	Wyton	1957-1980	✓	x	-
3414	Woburn	1951-1980	x	x	✓
3454	Silsoe	1951-1980	(x)	(x)	✓
3456	Cardington	1957-1980	✓	✓	x
3462	Luton	1967-1980	✓	✓	✓
3515	Bovingdon	1957-1967	✓	✓	-
3532	Aldenham School	1964-1980	✓	✓	-
3534	Garston	1961-1980	✓	✓	✓
3537	Rothamsted	1952-1980	✓	(x)	x
3544	St Albans	1951-1980*5	✓	(x)	✓
3559	Letchworth	1965-1973*6	-	✓	-
3582	Stanstead Abbotts	1958-1980	✓	x	-
3583	Hoddesdon	1959-1980	(x)	x	✓
3605	Little Parndon	1967-1978	✓	✓	-
3615	Harlow	1963-1980*7	x	✓	✓
3626	Stansted	1952-1980	✓	✓	-
3644	Writtle	1951-1980	x	✓	✓
3661	Southend	1959-1970	✓	✓	✓
3664	Maldon	1959-1978	✓	✓	-
3667	Earls Colne	1951-1975	✓	✓	-
3671	Shoeburyness	1952-1980	✓	✓	✓

*1 Sunshine = 1972-1980; *2 Sunshine = 1968-1980; *3 Sunshine only; *4 Sunshine = 1966-1980;

*6 Observations in 1978, 1979; *7 Sunshine = 1966-1979;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
3691	Clacton-on-Sea	1951-1980	x	✓	✓
3696	Walton-on-Naze	1962-1973*1	✓	✓	✓
3698	Dovercourt	1959-1974	✓	✓	✓
4002	Slaidburn	1954-1980	✓	x	✓
4016	Malham Tarn	1951-1980*2	x	✓	-
4041	Huddersfield	1959-1977	✓	✓	✓
4043	Huddersfield (Oakes)	1951-1972*3	/	x	✓
4045	Bradford	1951-1980	(x)	✓	✓
4047	Ilkley	1951-1980	✓	x	✓
4057	Harrogate	1953-1980	✓	x	✓
4061	Sheffield	1951-1980	✓	x	✓
4074	Pontefract	1951-1980*4	✓	✓	-
4076	Bramham	1953-56, 1959-80*5	✓	✓	x
4086	Cawood	1952-1980	✓	x	✓
4088	Askham Bryan	1951-1980	✓	x	✓
4112	Buxton	1951-1980*6	✓	✓	✓
4162	Mackworth	1960-1974	✓	✓	-
4164	Belper	1959-1973	✓	✓	-
4172	Derby	1955-1980	✓	✓	✓
4174	Morley	1959-1978	✓	x	✓
4176	Wingerworth	1968-1980*7	✓	✓	✓
4201	Sutton Bonington	1951-1980	✓	✓	✓
4206	Watnall	1956-1980	✓	✓	x
4217	Mansfield	1951-1980	✓	✓	-
4223	Nottingham	1951-1980	✓	✓	-
4237	Warsop	1952-1980	✓	✓	✓
4248	Finningley	1951-54, 1958-72	(x)	✓	✓
4316	Newton Linford	1959-1980	✓	✓	✓
4341	Caldecott	1957-1980	x	✓	✓
4362	Bugbrooke Mills	1964-1978	✓	✓	✓
4382	Raunds	1951-1980	x	✓	✓
4395	Marholm	1965-1980	✓	✓	-
4396	Wittering	1955-1972	x	✓	✓
4403	Birmingham(King Edwards School)	1952-1979	✓	✓	-
4406	Edgbaston	1952-1979	(x)	(x)	✓
4423	Luddington	1968-1980	✓	✓	✓
4432	Stratford-Upon-Avon	1951-1980	(x)	✓	✓
4441	Shipston-on-Stour	1951-1980	✓	x	✓

*1 Sunshine = 1962-1974; *2 Sunshine = 1957-1971; *3 Also 1977-1980, Sunshine = 1957-1972;

*4 Sunshine = 1951-1960; *5 Sunshine = 1953-56, 1959-72;

*6 Sunshine = 1951-1974; *7 Sunshine = 1970-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
4447	Elmdon	1951-1980	✓	✓	✓
4453	Wellesbourne	1951-1980	(x)	✓	✓
4463	Moreton Morrell	1954-1980	✓	✓	✓
4495	Rugby	1954-64, 1971-80	✓	x	-
4504	Brize Norton	1968-1980*1	✓	✓	-
4522	Oxford	1952-1980	✓	✓	✓
4542	Shirburn Model Farm	1969-1980	✓	✓	-
4561	Medmenham	1962-1980	✓	✓	-
4567	Grendon Underwood	1964-1980	x	✓	✓
4574	Aylesbury	1952-1980	✓	✓	✓
4617	Keele	1952-1980	x	(x)	x
4622	Oaken	1951-1980	✓	x	-
4636	Stone	1953-1980	x	✓	✓
4643	Penkridge	1956-1980*2	✓	✓	-
4662	Walsall	1951-1971*3	x	x	-
4668	Onecote	1959-1969	✓	✓	✓
4708	Oswestry	1951-1980	x	✓	✓
4737	Church Stretton	1959-1970*4	-	-	✓
4746	Shrewsbury	1951-1980	(x)	x	✓
4757	Shawbury	1951-1980	x	x	✓
4782	Bridgnorth	1959-1972*5	-	-	✓
4787	Newport (Salop)	1951-1980	(x)	✓	x
4792	Hampton Loade	1969-1980	✓	✓	✓
4813	Malvern	1951-1980	x	x	✓
4825	Worcester	1959-1969	✓	✓	✓
4833	Pershore College of Horticulture	1955-1980	x	✓	✓
4834	Pershore	1957-1977	(x)	✓	✓
4858	Lyonshall	1951-1980	✓	x	-
4882	Ross-on-Wye	1952-1976	✓	✓	✓
4886	Preston Wynne	1951-1980	x	✓	✓
4913	Filton	1951-1980	✓	✓	✓
4946	Hempsted	1959-1975	x	✓	✓
4948	Gloucester	1961-1979	x	x	✓
4967	Cheltenham	1951-54, 1959-80	✓	✓	✓
4972	Cirencester	1959-1973*6	✓	✓	✓
4995	Little Rissington	1951-1976	x	x	x
5025	Kensington Palace	1959-1978	✓	✓	-
5028	Hampstead	1951-1980	✓	✓	✓

*1 Sunshine = 1973-1980; *2 Sunshine recorded from 1978; *3 Also 1977-1980;

*4 Sunshine only; *5 Sunshine only; *6 Sunshine = 1959-1970.

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
5034	St James's Park	1951-1980	√	√	-
5036	Regents Park	1959-1970	√	√	√
5038	Camden Square	1959-1969	√	√	-
5046	London Weather Centre	1965-1980*1	-	-	√
5076	Greenwich	1951-1980*2	√	√	√
5113	Heathrow	1951-1980*3	√	x	√
5131	Hampton	1951-1980	√	√	√
5147	Wealdstone (Temperatures) (Sunshine)	1951-1962 1959-1980	√	√	√
5185	Southgate	1951-1980	√	√	√
5237	Wisley	1951-1980	x	√	√
5255	Mickleham	1951-1980*4	√	√	-
5258	Kew (PSYCH)	1969-1980	√	√	√
5259	Kew (N.W.S.)	1957-1977*5	√	√	√
5271	Gatwick	1958-1980	√	√	√
5287	Waddon	1951-1980*6	√	x	-
5297	Addington	1959-1973	√	√	-
5307	Bromley	1951-1980	√	√	-
5319	Dartford	1959-1969	√	√	-
5323	Hadlow College	1966-1980*7	√	√	√
5331	Goudhurst	1951-1980	x	x	-
5336	East Malling	1951-1980	√	√	√
5347	Gillingham	1951-1980*8	√	x	√
5365	Throwley	1959-1975	√	√	√
5367	Faversham	1957-1980	(x)	x	√
5370	Dungeness	1957-1979	√	√	-
5375	Wye	1951-1980	√	√	√
5379	Whitstable	1959-1974	√	√	√
5381	Folkestone	1951-1971	√	√	√
5386	Elmstone	1959-1972	√	√	-
5389	Herne Bay	1959-1970	√	√	√
5390	Dover	1959-1976	√	√	√
5392	Dover (RMS)	1951-1979	X	√	-
5394	Deal	1958-1971	√	√	-
5396	Manston	1961-1980*9	√	x	-
5399	Margate	1951-1980	√	√	√
5401	Thorney Island	1957-1976	(x)	√	√
5405	Rogate	1969-1980	√	√	-

*1 Temperatures = 1974-1980; *2 Sunshine = 1952-1980; *3 Sunshine = 1959-1980;

*4 No data 1978; *5 Sunshine = 1957-1976; *6 Gaps in 1968, 1969 (Max Temp), Sunshine = 1951-1958;

*7 Sunshine = 1968-1980; *8 Sunshine = 1953-1966; *9 Sunshine = 1973-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
5411	Bognor Regis	1951-1980	√	x	√
5418	Fernhurst	1959-1980	√	x	√
5420	Littlehampton	1959-1979	√	√	√
5421	Rustington	1960-1980*1	√	√	√
5426	North Heath	1968-1980	√	√	√
5431	Worthing	1951-1971	√	√	√
5441	Brighton	1951-1980	√	√	√
5453	Plumton	1965-1980*2	√	√	√
5464	East Hoathly	1963-1980	√	√	√
5471	Eastbourne	1951-1980	√	√	√
5472	Eastbourne Coastguard	1957-1974	√	x	-
5480	Bexhill	1951-1980	√	√	√
5488	Bodiam	1959-1975	√	√	√
5490	Hastings	1952-1980*3	√	√	√
5516	Letcombe Regis	1960-1980	√	√	-
5537	Abingdon	1957-1975	√	√	√
5545	Compton	1959-1969	-	-	-
5558	Wallingford	1960-1980	√	√	√
5575	Shinfield	1959-1975	√	√	√
5576	Reading (Whiteknights)	1968-1980	√	√	√
5578	Reading Univeristy	1951-55, 1959-67	√	√	√
5581	Finchampstead	1959-1973	√	√	√
5588	Hurley	1952-1980	*	√	√
5592	Easthampstead (Beaufort Park)	1971-1980	√	√	-
5601	Bournemouth	1959-1978	√	√	√
5603	Hurn	1952-1980*4	√	√	√
5612	Christchurch	1955-1980	√	√	-
5631	Everton	1953-1980	√	√	√
5642	Southampton(Mayflower Park)	1969-1980	√	√	√
5643	Southampton (East Park)	1952-1969	√	x	√
5647	Leckford	1951-1980	√	√	√
5656	Winchester	1958-1979*5	√	√	√
5666	Martyr Worthy	1955-1980	√	√	√
5670	Southsea	1951-1980	√	√	√
5680	Hayling Island	1954-1980	√	√	√
5687	Long Sutton	1951-1980	√	√	√
5694	Alice Holt Lodge	1951-1980*6	√	x	√
5696	South Farnborough	1951-1975	√	√	x

*1 No Data 1972; *2 Sunshine = 1966-1980, No Data 1966 (Min Temp);

*3 No Data 1967; *4 Sunshine = 1967-1980; *5 No Data 1976; *6 Sunshine = 1954-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
5760	St Catherines Point	1964-1980	√	√	-
5771	Wight Ventnor Park	1951-1980	√	√	√
5782	Shanklin	1951-1980	√	√	√
5790	Sandown	1951-1980	x	x	√
5798	Ryde	1951-1980	√	x	√
5827	Lacock	1951-1980*1	√	√	-
5848	Lyneham	1951-1980*2	√	√	√
5863	Larkhill	1951-1980	√	√	-
5872	Boscombe Down	1951-1980	√	x	√
5874	Upavon	1954-1980	√	√	-
5877	Marlborough	1951-1980	√	√	√
5882	Porton	1951-1980	√	x	√
6007	Tiree	1952-1980	√	√	√
6022	Rhuvaal	1957-1980	x	x	-
6024	Colonsay	1959-1980	x	x	-
6025	Aros	1967-1980	√	√	-
6050	Machrihanish	1965-1980	√	√	√
6041	Campbeltown	1960-1972*3	√	√	√
6053	Achaglachgaach	1959-1978	√	x	-
6074	Glenbranter	1965-1976, 1980	√	√	-
6085	Benmore(Younger Botanic Gardens)	1960-1980	√	√	-
6130	Kildonan	1965-1980*4	√	√	-
6133	Brodick Castle	1965-1980	√	√	-
6169	Rothesay	1959-1980*5	x	√	√
6186	Millport	1959-68, 1973-80	√	√	-
6213	Helensburgh	1959-1979	x	x	√
6218	Sloy	1965-1978	√	√	-
6238	Cumbernauld	1961-1975	√	√	-
6276	Earls Hill	1961-1980	(x)	x	√
6287	Stirling (Batterflats)	1960-66, 1970-80*6	√	√	√
6288	Stirling	1959-1970*7	√	√	-
6293	Falkirk(Sewage Works)	1967-1980*8	√	√	√
6296	Grangemouth	1967-1979*9	-	-	-
6318	Greenock	1951-76, 1980*10	x	x	√
6366	Paisley	1951-1980	√	√	√
6374	Barrhead	1959-1977	x	x	-
6378	Renfrew	1952-1966	x	√	√
6379	Abbotsinch	1966-1980	√	√	√

*1 No Data 1956; *2 Sunshine = 1952-1980; *3 Sunshine = 1960-1975; *4 No Data 1974;

*5 Sunshine. No Data 1977-78; *6 Sunshine = 1970-1980; *7 Sunshine = 1962-1970;

*8 Sunshine = 1968-1980; *9 Record contains many gaps; *10 Sunshine = 1951-1980.

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
6406	Crossmyloof	1963-1973*1	√	√	-
6418	Springburn	1951-1980*2	√	x	√
6426	East Kilbride	1971-1980	√	√	√
6437	Coatbridge	1959-1980	√	x	-
6462	Leadhills	1959-1980	√	x	-
6463	Crawfordjohn	1961-1980	x	√	√
6467	Lanark	1964-72, 1979-80*3	√	-	√
6478	Carnwath	1952-1980	x	x	-
6483	Camp's Reservoir	1964-1980	√	√	√
6513	Girvan	1968-1980	√	√	√
6518	Hunterston	1965-1980	√	x	-
6544	Auchincruive	1951-1980	√	x	x
6547	Prestwick	1951-1980	(x)	x	x
6558	Kilmarnock	1965-72, 1979-80*4	-	-	-
6612	Dalmacallan	1959-1969	√	√	-
6641	Dumfries	1952-1980	(x)	√	x
6677	Eskdalemuir (PSYCH)	1971-1980	√	√	√
6679	Eskdalemuir (S.Screen)	1954-1980*5	√	√	√
6704	Bargrennan	1959-1980	√	x	-
6732	Palnure	1959-1980	x	x	-
6735	Clatteringshaws	1965-1980	x	√	√
6745	Glenlee	1951-1980	√	√	-
6747	Dundeugh	1959-1980	x	√	-
6764	Glenlochar Barrage	1959-1980	√	√	-
6772	Threave	1961-1980	√	√	-
6837	Penwirn	1959-1980	√	√	√
6840	Mull of Galloway	1957-1971	√	√	-
6896	Newton Stewart	1964-1980*6	√	√	-
6921	Ronaldsway	1951-1980	x	√	√
6951	Douglas	1952-1980	√	x	√
6989	Point of Ayre	1951-1980	x	x	√
7001	Sellafield	1951-1980	-	-	-
7050	Carlisle	1961-1980	√	√	√
7071	Newton Rigg	1951-1980	√	√	√
7087	Spadeadam	1959-1973	√	√	√
7115	Ambleside	1959-1970	√	√	√
7178	Great Dun Fell	1963-1973*7	-	-	√
7188	Moor House	1952-1980*8	√	√	√

*1 Sunshine = 1963-1972; *2 Sunshine, No Data 1979; *3 Sunshine = 1964-1980, No Data 1978,

*4 Sunshine = 1965-1972; *5 Sunshine = 1954-1976; *6 No Data 1975-76;

*7 Temperatures = 1963-1972; *8 Sunshine = 1953-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
7213	Squires Gate	1951-1980	✓	✓	✓
7218	Urswick	1959-1969	-	-	-
7221	Aigburth Gate	1967-1980*1	✓	✓	✓
7223	Southport	1951-1980	x	x	x
7226	Poulton-Le-Fylde	1959-1975	✓	✓	-
7228	Cartmel	1969-1980	✓	✓	-
7229	Grizedale	1960-1980	✓	✓	-
7230	Speke	1957-1977	x	x	x
7235	Kirkham	1951-1980	x	✓	✓
7237	Garstang	1959-1969	✓	✓	✓
7238	Bailrigg	1966-1976	-	-	-
7239	Morecambe	1952-1980	x	✓	✓
7245	Preston (Moor Park)	1951-1980	✓	✓	-
7263	Bolton	1958-62, 1966-80	x	x	✓
7269	Stonyhurst	1969-1979	✓	✓	✓
7272	Manchester Weather Centre	1961-1980*2	-	-	✓
7275	Helmshore	1952-1980	✓	✓	✓
7287	Burnley (Marsden Hospital)	1959-1971	✓	✓	✓
7288	Nelson	1959-1976	✓	✓	✓
7304	West Kirby Park	1959-1979*3	✓	✓	✓
7326	Ness Gardens	1965-1980*4	✓	✓	✓
7346	Winnington	1959-1976	✓	✓	-
7366	Knutsford	1961-1980	✓	✓	-
7377	Ringway	1951-1980	✓	x	✓
7384	Macclesfield	1951-1980	x	✓	-
7408	Rhyl	1951-74, 1979-80	✓	✓	✓
7418	Prestatyn	1951-1980*5	✓	x	✓
7467	Hawarden Bridge	1951-1980	✓	✓	-
7511	Valley	1952-1980	✓	x	x
7609	Colwyn Bay	1971-1980	✓	✓	-
7623	Alwen	1956-1980	*	✓	✓
7657	Ruthin	1959-1980*6	✓	✓	✓
7665	Loggerheads	1961-1980*7	✓	✓	✓
7678	Bwlchgwyn	1951-1980	x	✓	-
7696	Wrexham	1959-1974	✓	✓	-
7713	Botwnnog	1960-1980	✓	✓	✓
7748	Pen-Y-Ffridd	1953-1980	x	x	✓
7768	Aber	1951-1980	✓	✓	(x)

*1 Sunshine = 1967-74, 1977-80; *2 Temperatures = 1974-1980; *3 Sunsine = 1959-1975;

*4 Sunshine = 1968-1980; *5 No Data 1975; *6 No Data for 1971, Sunshine = 1965-1980;

*7 Sunshine = 1968-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
7824	Trawsfynydd	1961-1980	✓	✓	-
7866	Bala	1970-1980	✓	✓	✓
7884	Corwen	1958-1980	✓	✓	-
7905	Ceinws	1961-1976	✓	✓	-
7912	Moel Cynnedd	1968-1980	✓	✓	-
7947	Lake Vyrnwy	1953-1980	✓	✓	-
8009	Aberporth	1951-1980	✓	x	✓
8056	Aberystwyth	1959-1979*1	✓	✓	✓
8058	Aberystwyth	1952-1969	✓	x	✓
8068	Gogerddan	1954-1980	✓	x	✓
8073	Swyddffynnon	1959-1973*2	✓	✓	✓
8076	Trawscoed	1951-1980	✓	✓	✓
8078	Llety-Evan-Hen	1951-1977	x	✓	✓
8086	Cwmystwyth	1959-1980	✓	✓	✓
8122	Dale Fort	1951-1980*3	✓	✓	✓
8132	Milford Haven C.B.	1964-1980	✓	✓	-
8142	Orielton	1964-1980	✓	✓	-
8154	Haverfordwest	1952-1964	✓	✓	✓
8235	Carmarthen	1962-1980	✓	✓	✓
8293	Brynamman	1969-1980	*	✓	-
8314	Llandrindod Wells	1951-1974	✓	✓	✓
8362	Llwynon	1952-1979	✓	✓	✓
8403	Whiteford Burrows	1968-1980	✓	-	-
8410	Mumbles Head	1958-1980	x	✓	-
8411	Penmaen	1968-1971*4	✓	✓	✓
8413	Swansea	1951-1980*5	✓	✓	x
8421	Port Talbot	1959-1979	✓	✓	✓
8424	Neath	1955-1980	✓	✓	-
8431	Porthcawl	1951-1980	✓	x	✓
8471	Rhoose	1954-1980	✓	x	✓
8492	Cardiff	1951-1976	✓	✓	x
8507	Tredegar	1951-1974	✓	✓	✓
8532	Newport (Mon)	1953-1977	✓	✓	✓
8555	USK	1959-1980	✓	✓	✓
8585	Crumbland Plantation	1957-1980	x	✓	✓
8603	Hawkridge	1958-1980*6	✓	✓	✓
8633	Nettlecombe	1968-1980	✓	✓	-
8637	Cannington	1951-1978	x	x	✓

*1 Sunshine = 1959-1975; *2 Sunshine = 1960-1973; *3 Sunshine = 1952-1980

*4 Sunshine = 1971-1980; *5 Sunshine = 1951-1971 + A few other observations;

*6 Sunshine = 1963-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
8648	Weston Super Mare	1959-1971	✓	✓	✓
8673	Yeovilton	1964-1980	✓	✓	-
8677	Rodney Stoke	1964-1980	✓	✓	-
8678	Long Ashton	1951-1980	✓	✓	✓
8686	Downside Abbey	1968-1980	✓	✓	-
8692	Wincanton	1962-1980*1	✓	✓	-
8697	Bath	1954-1980*2	✓	✓	-
8722	Weymouth	1970-1980	✓	✓	✓
8723	Portland RNAS	1957-1968	✓	✓	-
8731	Portland Bill Coastguard	1967-1980	✓	✓	✓
8733	Weymouth	1951-1969	✓	x	✓
8752	Winfrith	1962-1980	✓	✓	-
8768	Shaftesbury	1951-1975	✓	✓	-
8781	Swanage	1951-1980	x	✓	x
8785	Poole	1964-1980	✓	✓	✓
8807	Hartland Point	1951-1980	✓	✓	✓
8811	Mount Batten	1952-1980	✓	x	✓
8812	Plymouth Hoe	1959-1980	x	✓	✓
8814	Tavistock	1961-1979	✓	✓	-
8823	North Hessary Tor	1963-1980	✓	✓	-
8827	Chivenor	1957-1974	✓	✓	✓
8829	Ilfracome	1952-1980	✓	✓	✓
8834	Princetown	1963-66, 1972-80	✓	✓	-
8851	Slapton	1960-1980	✓	✓	-
8855	Newton Abbot	1959-1976	✓	x	✓
8864	Torbay (Torquay)	1951-1980	✓	✓	✓
8871	Teignmouth	1951-1979	✓	x	✓
8873	Starcross	1951-1980	✓	✓	✓
8881	Exmouth	1951-1980	✓	x	✓
8884	Exeter	1951-1980	✓	✓	x
8891	Sidmouth	1951-1980*3	✓	x	x
8902	Scilly(St Marys)	1952-1980	✓	x	✓
8913	Penzance	1951-1980	✓	x	✓
8915	Gulval	1951-1980*4	✓	✓	✓
8922	Culdrose	1960-1980	✓	✓	✓
8928	Rosewarne	1953-1980	✓	✓	x
8930	Lizard	1959-1980	✓	✓	✓
8942	Falmouth	1952-1980	✓	✓	✓

*1 Sunshine = 1976-1980; *2 Sunshine = 1963-1970; *3 No Data 1976, Sunshine = 1951-1974;

*4 No Data 1979.

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
8946	Newquay	1951-1980	√	√	√
8957	St Mawgan	1955-1980	√	√	√
8963	St Austell	1959-1976	√	√	-
8971	Fowey	1951-1980	x	x	-
8986	Bastreet	1970-1980	√	√	√
8987	Bude	1951-1980*1	√	√	√
8993	Ellbridge	1959-1977	√	x	√
9025	Loughermore Forest	1961-1980	√	√	-
9036	Ballykelly	1957-1971	√	√	√
9042	Banagher (Caugh Hill)	1969-1980*2	√	√	-
9053	Derrynoyd Forest	1961-1980	√	√	-
9077	Coleraine University	1969-1980	√	√	√
9085	Garvagh Forest	1961-1980	(x)	√	-
9086	Moneydig	1968-1980	√	√	-
9117	Ballymoney	1964-1977	√	√	-
9134	Lisnafillan	1967-1980	√	√	√
9142	Aldergrove	1952-1980	(x)	(x)	√
9143	Greenmount	1963-1980*3	√	√	-
9147	Altnahinch Filters	1965-1980	√	√	√
9157	Parkmore Forest	1956-60, 1967-80	*	√	-
9162	Divis Mountain	1962-1980	x	√	-
9167	Lowtown	1965-1980	√	x	√
9169	Ballypatrick Forest	1961-1980*4	√	√	√
9170	Belfast (Malone)	1967-1980*5	√	√	-
9175	Newtownabbey	1967-1979	√	√	√
9185	Woodburn North	1967-1980	√	√	-
9188	Larne	1961-1975	√	√	-
9190	Kilroot	1963-1975	√	√	-
9199	Ballylumford	1967-1980	√	√	-
9238	Hillsborough	1951-1980	√	√	x
9241	Kilkeel	1953-60, 1968-75*6	√	√	-
9253	Tollymore Park	1960-1970	√	√	-
9257	Rosetta	1967-1979	√	√	-
9260	Murlough	1968-1980*7	*	√	√
9268	Stormont Castle	1957-1980*8	(x)	√	x
9273	Downpatrick	1969-1980	√	√	-
9279	Creighton's Green	1959-1977	x	√	-
9284	Reagh Island	1960-1971	√	√	-

*1 Break in sunshine data Dec'66-Sept'68; *2 Sunshine = 1974-1980;

*3 Sunshine = 1975-1980; *4 Sunshine = 1966-1980; *5 Sunshine = 1967-1969 (misc.); 1974-1980;

*6 Sunshine = 1968-70, 1970-75; *7 Sunshine = 1969-1980; *8 Sunshine = 1961-1980;

STATION DCNN	STATION NAME	PERIOD OF RECORD	MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	SUNSHINE
9288	Helens Bay	1961-1980*1	√	√	√
9295	Ballywater Park	1970-1980*2	-	-	√
9336	Armagh	1951-1980	x	√	x
9347	Loughgall	1957-1980	(x)	x	x
9375	Tandragee (Ballylisk)	1970-1980	√	√	-
9383	Bessbrook	1960-1972*3	-	-	√
9388	Partadown S.Wks	1965-1975	√	√	-
9398	Lurgan Cemetery	1966-1980*4	√	√	√
9412	Lough Bradan	1961-1980	√	x	√
9427	Baronscourt Forest	1961-1973	*	√	-
9429	Strabane	1967-1980*5	√	√	√
9433	Carrigans	1963-1980*6	√	√	-
9434	Lislap Forest	1959-1973	√	√	-
9443	Knockmany Forest	1961-1973	√	√	-
9465	Pomeroy Forest	1962-1980	x	√	-
9488	Cookstown	1967-1980	√	√	√
9515	Lough Navar Forest	1961-1980	*	x	-
9547	Castle Archdale Forest	1963-1980	√	√	√
9574	Lisnaskea Creamery	1965-1980*7	√	√	√
9577	Pubble Forest	1961-1978	√	√	-
9912	Guernsey (Airport)	1951-1980*8	√	√	√
9928	Guernsey Langresse	1966-1980	√	√	√
9947	Alderney	1959-1979	√	x	√
9965	Jersey Airport	1953-1980*9	√	√	√
9969	Jersey St Helier Harbour	1951-60, 1966-69	x	√	√
9970	Jersey-St Helier(Observatory)	1970-1980	√	√	√

*1 Sunshine = 1967-1980; *2 Sunshine Only; *3 Sunshine Only; *4 Sunshine=1965-1980;

*5 Sunshine = 1968-1980; *6 Sunshine = 1972-1980; *7 Sunshine = 1966-1978;

*8 No Data 1959; *9 Sunshine = 1954-1980;

Appendix B

Graphs of mean annual RMS residuals for stations flagged by the homogeneity routine

Key to Appendix B

POSSIBLE CAUSES FOR INHOMOGENEITIES IDENTIFIED IN THE RESIDUALS

0088	Baltasound	1963	New site 1/1/63
		1957, 1969, 1972	New thermometers
0329	Cape Wrath		New minimum thermometers:- 1956, 1961, 1963, 1964, 1967, 1971, 1974, 1980. 1964 found to be reading 1°C too low at inspection.
0425	Stornoway	1973	New site 1/11/73
0443	Achnashellach	1957	Thermometers read to nearest °C; site moved a few yards.
		1962	Site moved slightly
		1966	New minimum thermometer, readings taken late in morning, corrected to 09Z.
0445	Kinlochewe		Sheltering by growth of trees
0516	Onich		Shelter increased over the 30 year period leading to an increase in the diurnal temperature range.
1215	Braemar	1963	New site (sunshine)
1351	Mylnefield	1969	1/4/69 New site
1577	Leuchars	1959	26/9/59 New site
		1969	21/8/69 New site
1963	Edinburgh-East Craigs	1971	New thermometers, also (15') glass-house noted 30' to west of site.
1646	Edinburgh-Blackford Hill	1955	New maximum thermometer
		1961	New Site

		1966	Enclosure moved
		1971	New screen and thermometers (most noticeable for minimum temperature)
1649	Edinburgh-Royal Botanic Garden	1961	New maximum thermometer
		1971/2	New maximum thermometer
1744	Marchmont	1957	Bushes observed near site in 1954 removed by 1957 inspection

GE

2034	Haydon Bridge	1954	Station opened on new site
		1971	1/11/71 Thermometers changed (deg F deg C)
		1977 onwards	Screen deteriorating rapidly
2084	Cockle Park	1954/5	Jan 1954-June 1955 records unreliable, values 1-5 deg F too low.
		1957	19/3/57 New site
		1966	11/10/66 Minimum thermometer reading 1.6 deg F too low.
		1967	April-Dec 1967 U-type max and min thermometers used with 3 deg F added at the station.
		1974	Site change noted by inspection.
2091	Tynemouth	1975	11/3/75 New site
2138	Chopwellwood	1950	5/5/50 New site
		1971	Thermometers changed (deg F deg C)
2295	Silpho Moor	1956	Jan 1956 New site
2337	High Mowthorpe	1960	New Site
2361	Hull	1953	Sunshine sphere found to transmit only 85% of sunlight
		1974	Position of instruments changed
2387	Bridlington	1959	pre 1959, problems with leveling of sunshine recorder.
2423	Waddington	1952/5	New site identified by photographs, date uncertain.
2432	Cranwell	1955	New site at some date between 1946-1955 identified from photographs - 1955?
		1971	New site 12/5/71
2478	Cleethorpes		Large number of gaps in the record.
3060	Cromer		Gaps in sunshine record

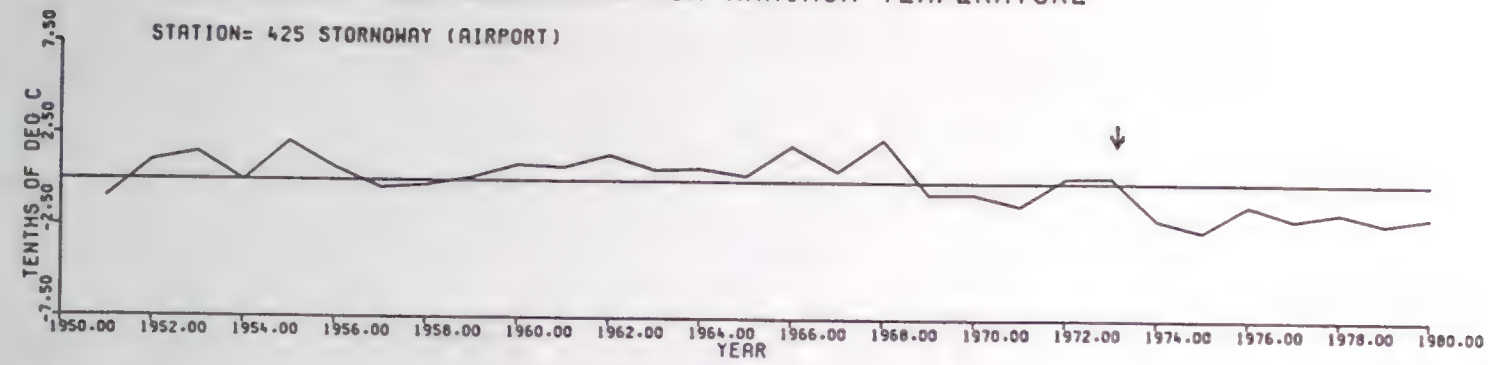
3084	Burlingham	1964/5	Change of site, moved 50 years north.
3141	East Bergholt	1971	Thermometers changed (deg F deg C)
3197	Lowestoft	1972/3	Screen moved to improve exposure
3414	Woburn	1957	1/1/57 New observer after 26 years
		1961	New site
3454	Silsoe	1970	9/11/70 New site
3537	Rothamsted	1973	New sunshine recorder
3582	Stanstead Abbots		Large number of gaps in the record
3583	Hoddesdon	1967	New site
4016	Malham Tarn	1956	Sheltering effect of trees noted
		1969	New site
4045	Bradford	1958	Jan 1958, max thermometer found to be acting as an ordinary thermometer (in use since 1938)
		1961	14/6/61 New thermometer (max)
		1970	Station described as in a poor condition
4047	Ilkley	1955	Minimum thermometer reading 1 deg F too low
4057	Harrogate	1953	New site (described as 'not ideal')
4061	Sheffield	1962	Possible new site 9/8/62
4086	Cawood	1958/60	New site
4088	Askham Bryan	1959	No evidence of N.P.L. corrections having been made for several years.
		1960	New site 12/10/60
		1971/2	New screen
		1974	New site - July 1974
4174	Morley		New minimum thermometers - 6/9/65, 31/12/71, 1972, 1975.
4341	Caldecott	1971	Dec 1971-New site
4382	Raunds	1957	Screen moved 12 ft south, no longer sheltered by hedge.

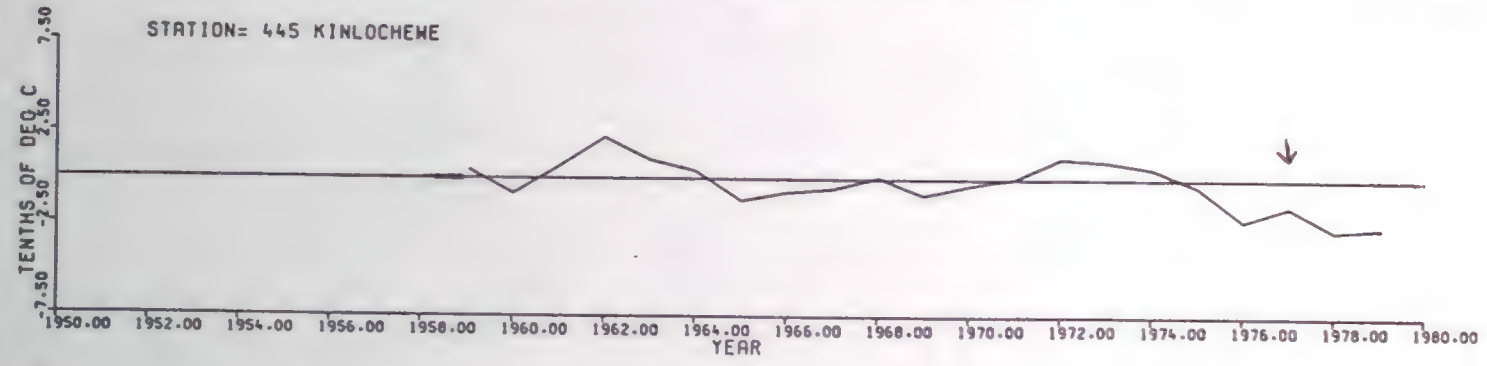
4432	Stratford-upon-Avon	1956	New site
4441	Shipston-on-Stour	1961/62	Minimum thermometer reading 1-2°F too low
4662	Walsall	1962	Observing time changed from 07 GMT to 08 GMT.
		1963/4	New site
		1980	Observing time changed to 09 GMT.
4746	Shrewsbury	1967	Jan 1967 - New site
4787	Newport (Salop)	1953	Serious obstructions to the sun, nearby glasshouses may affect temperatures.
		1958	New site
		1966	New site
		1971	Sphere described as 'amber'; 1972 noted that sunshine averages had been very low since 1958
		1973	New sphere
4813	Malvern	1955	New site
5237	Wisley	1965	1/1/65 new site
5331	Goudhurst	1954	No corrections made 1949-1954
		1961	New site
		1969	Surrounding trees lopped
5347	Gillingham	1952	New site
		1958	New site
5367	Faversham	1970	Screen moved to reduce effects of evaporation pan.
		1977 onwards	Site becoming more exposed.
5472	Eastbourne Coastguard	1964	21/10/64 New site
5694	Alice Holt Lodge	1955	April 1955 - New site
		1971	Described as sheltered to the north by trees.

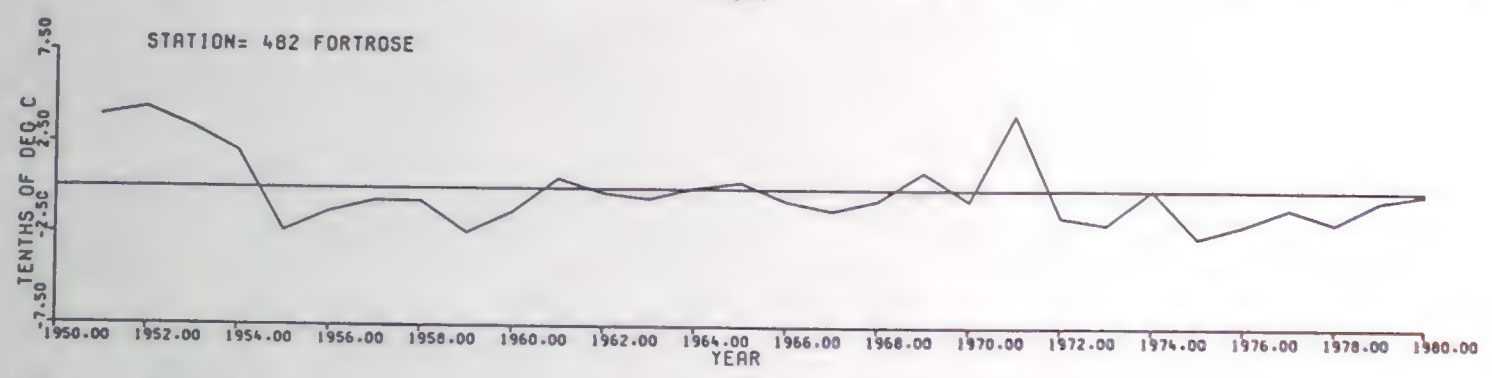
5790	Sandown	1971	Noted as 'definitely oversheltered'
		1975	8/7/75 - new site
6213	Helensburgh	1970	New site (DCNN changed)
6437	Coatbridge	1974	New site 20/12/74
6462	Leadhills	1973	New site 1/2/73
6478	Carnwath	1965	New site 1/1/65
6544	Auchincruive	1963	New site - sunshine
6547	Prestwick	1962	New site 17/4/62
7223	Southport	1956	Jan 1956 - new site
		1962	New site
		1965	Minimum thermometer found to be reading $0.9^{\circ}F$ too high.
7235	Kirkham	1953	5/1/53 - new site
			New maximum thermometers - 1/12/68, 2/1/72, 1974, 1976.
7263	Bolton		Considerable problems with trees
7377	Ringway		Urbanisation effects
7418	Prestatyn	1962/4	Screen, stand and thermometers replaced due to vandelism
		1971	26/6/71 - new site
7511	Valley	1963	Enclosure moved 50 yards 4/11/63
		1966	Enclosure moved 30 feet 21/5/66
		1968	New site for sunshine recorder 23/2/68
8078	Llety-evan-hen	1956	Maximum thermometer found to be grossly inaccurate, may have affected 1955 values.
8492	Cardiff	1960	New site - moved due to continued growth of trees
		1967	New site, poor with trees obstructing sphere
		1976	Station closed.

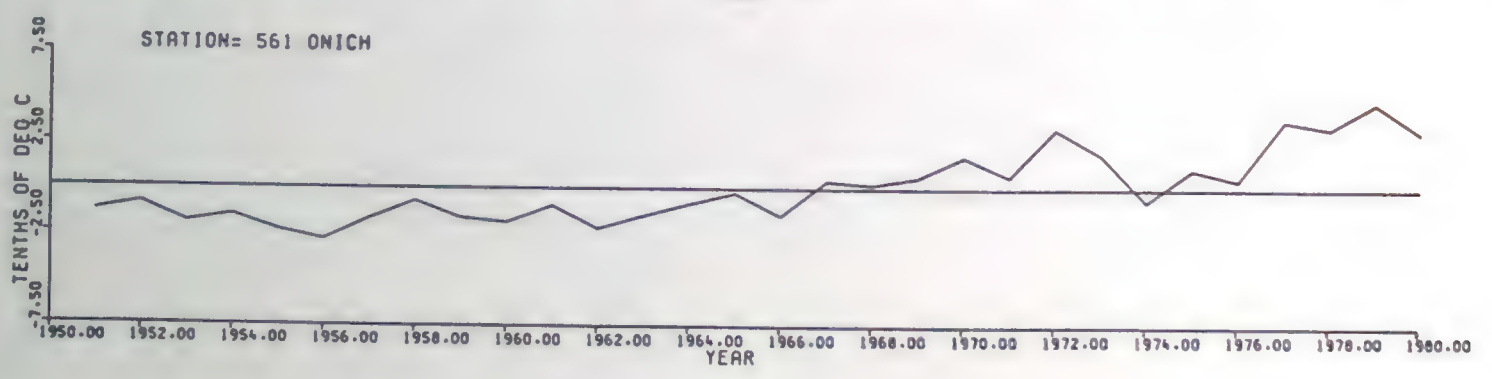
8585	Crumbland Plantation		Originally an excellent site but eventually located in a forest clearing.
8637	Cannington	1972	24/5/72 - New site.
8855	Newton Abbot	1963	Suggestion that a new sceen was installed.
8913	Penzance	1954	New site 27/7/54
8971	Fowey	1966	New site
		1969	New site - 27/11/69 - described as 'sheltered'
		1970	New screen - 24/2/70
		1974	New site 8/10/74
9167	Lowtown	1980	New site 1/4/80
9279	Creightons Green	1966	New site, considered homogeneous
9336	Armagh	1955	New site for sunshine recorder
9465	Pomeroy Forest	1974	New site 28/3/74

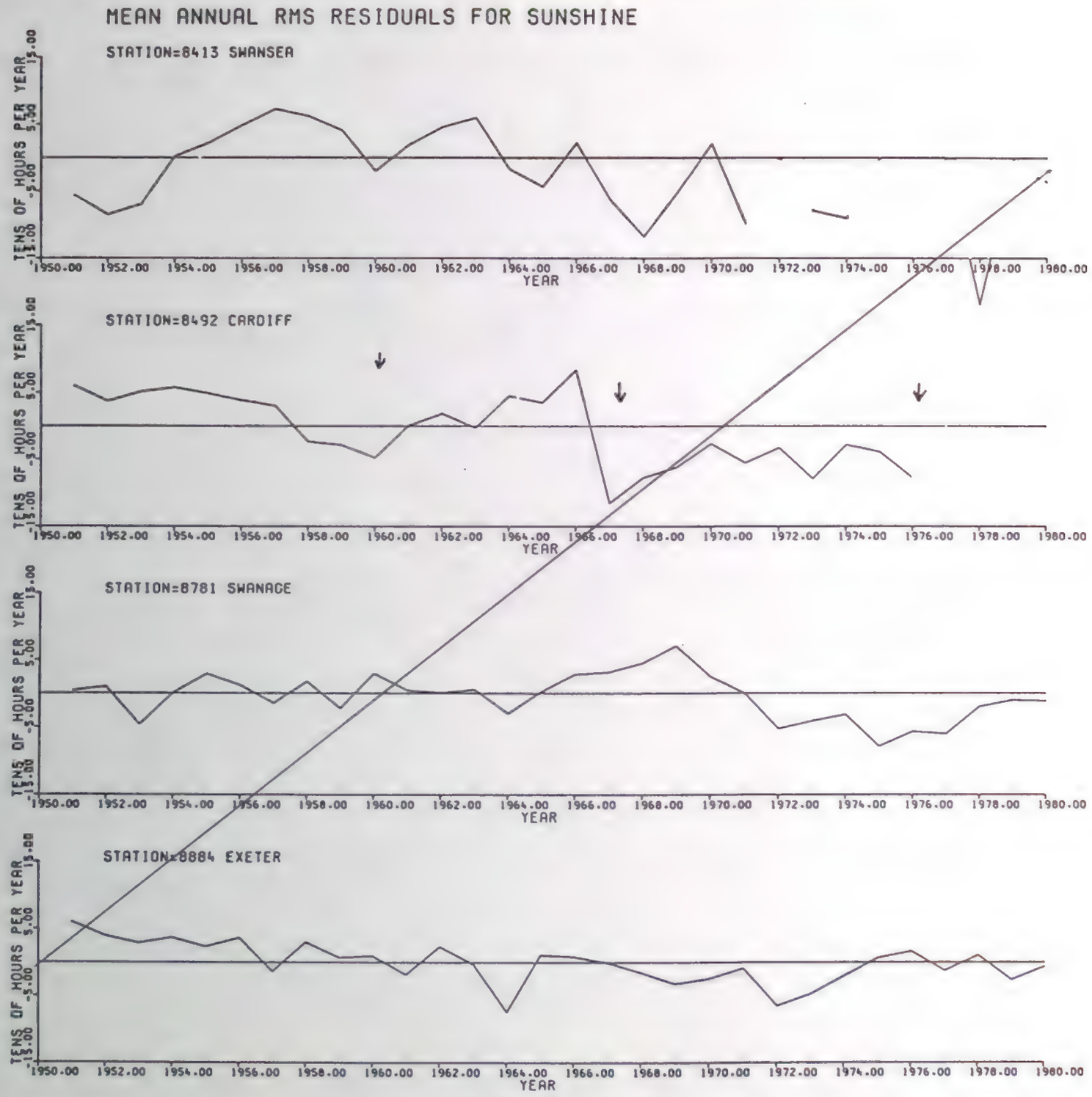
MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE







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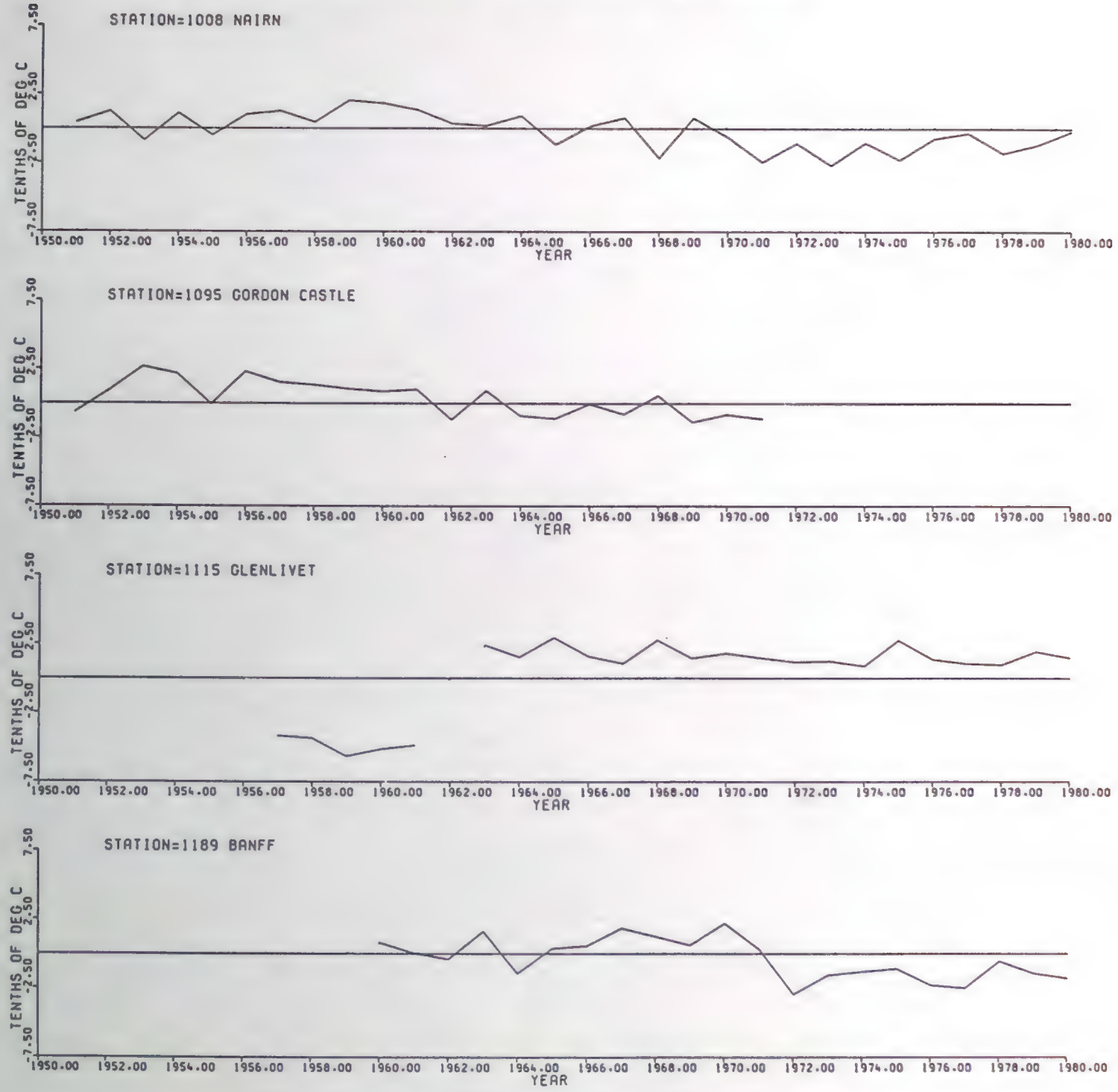
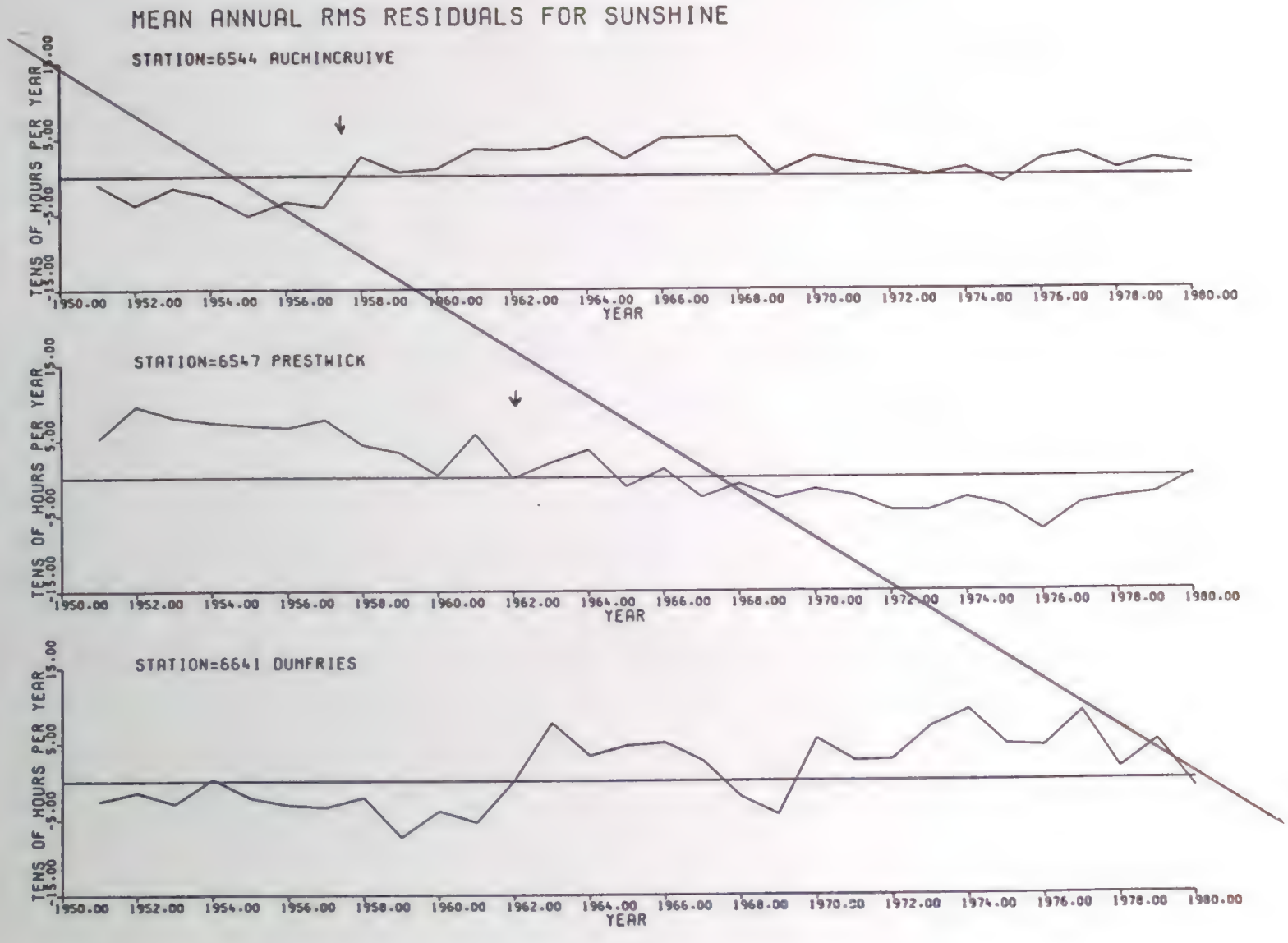
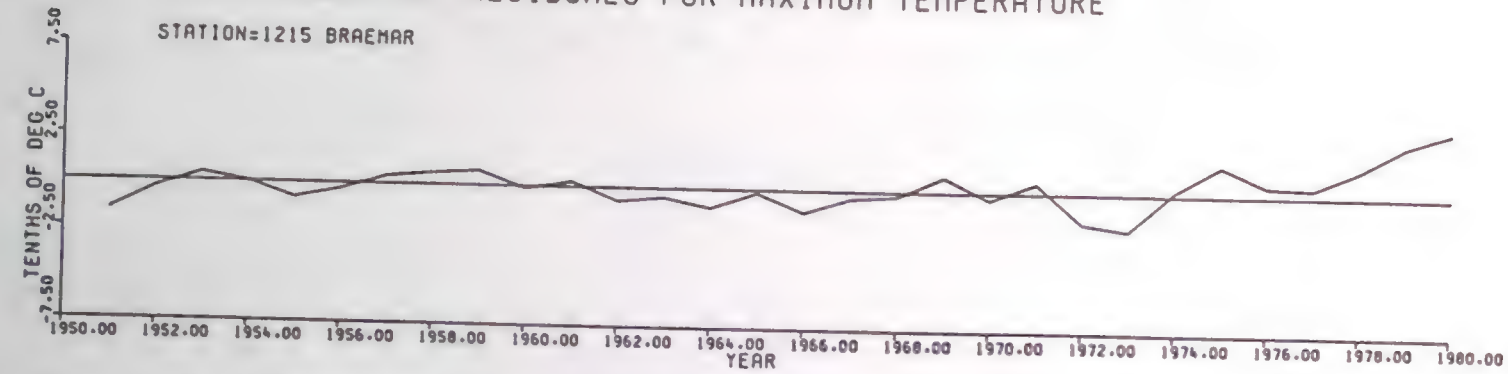
STATION=8492 CARDIFF
STATION=8781 SWANAGE
STATION=8884 EXETER
TENS OF HOURS PER YEAR
-15.00
-5.00
5.00
15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

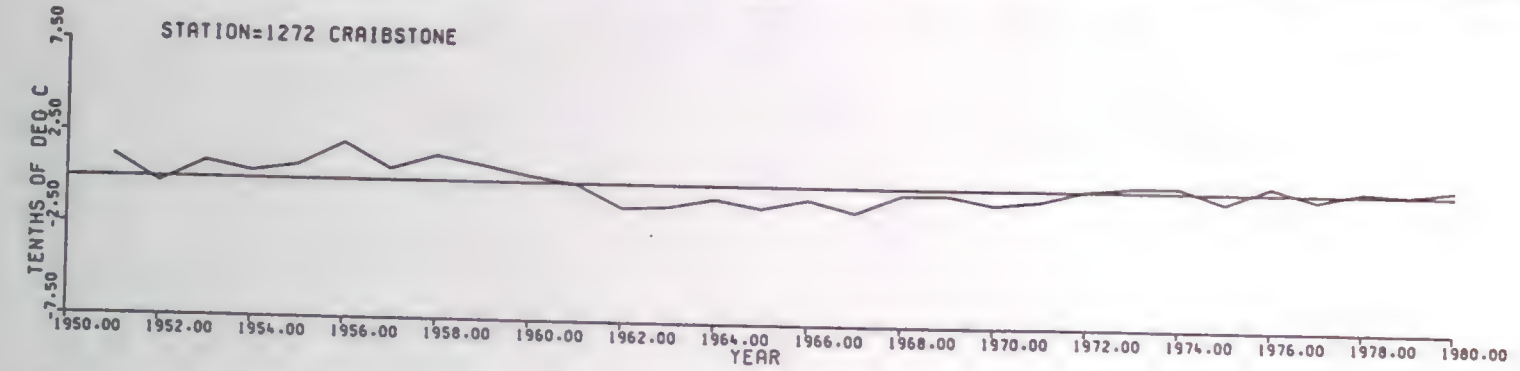
MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

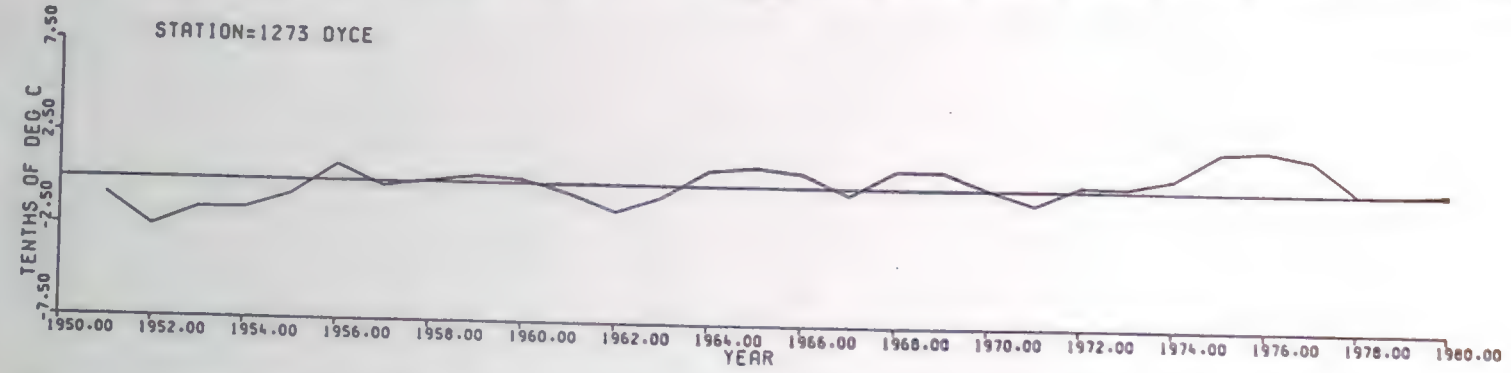


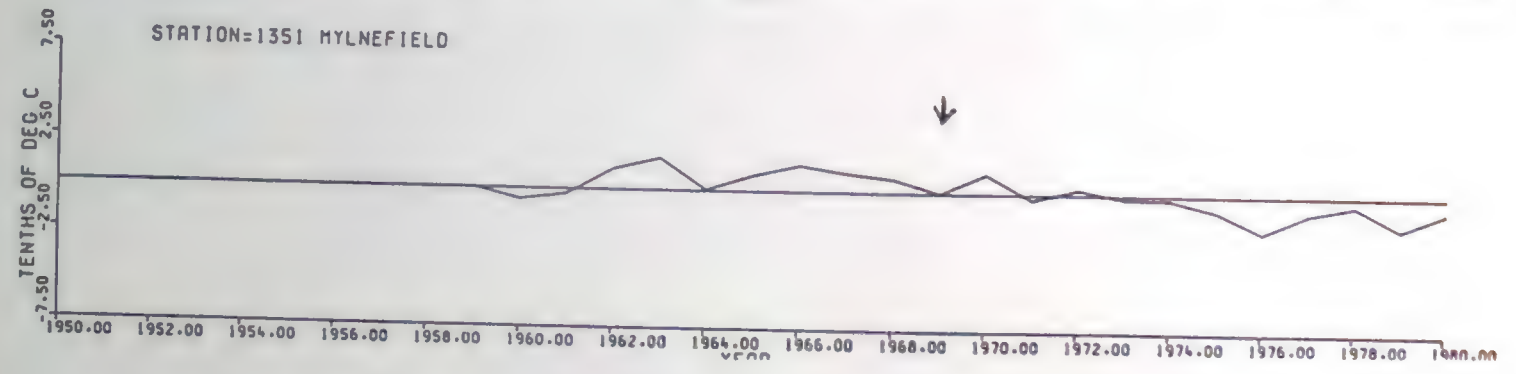

MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE
STATION=6544 AUCHINCRUIVE
STATION=6547 PRESTWICK
STATION=6641 DUMFRIES
TENS OF HOURS PER YEAR
15.00
5.00
-5.00
-15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE









MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

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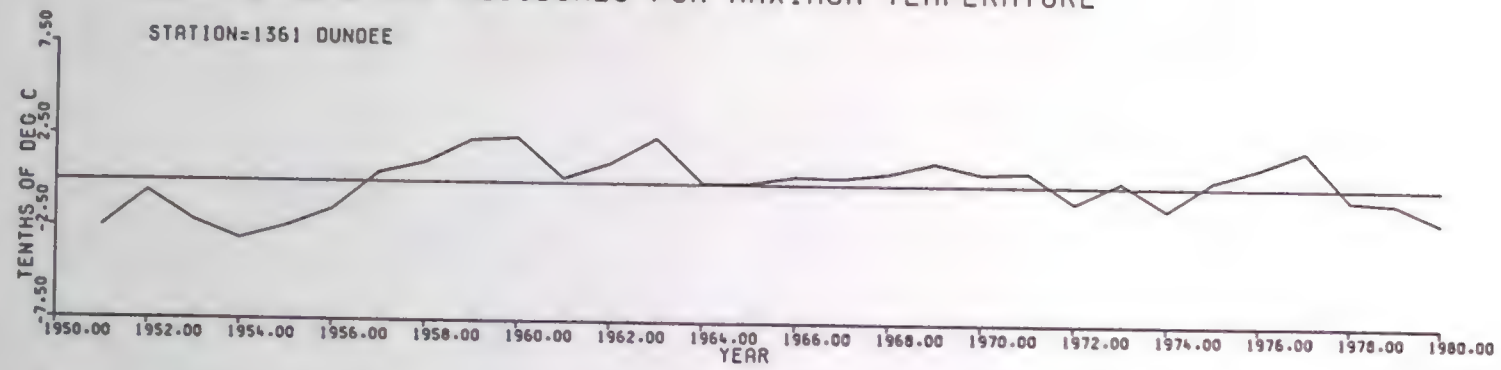
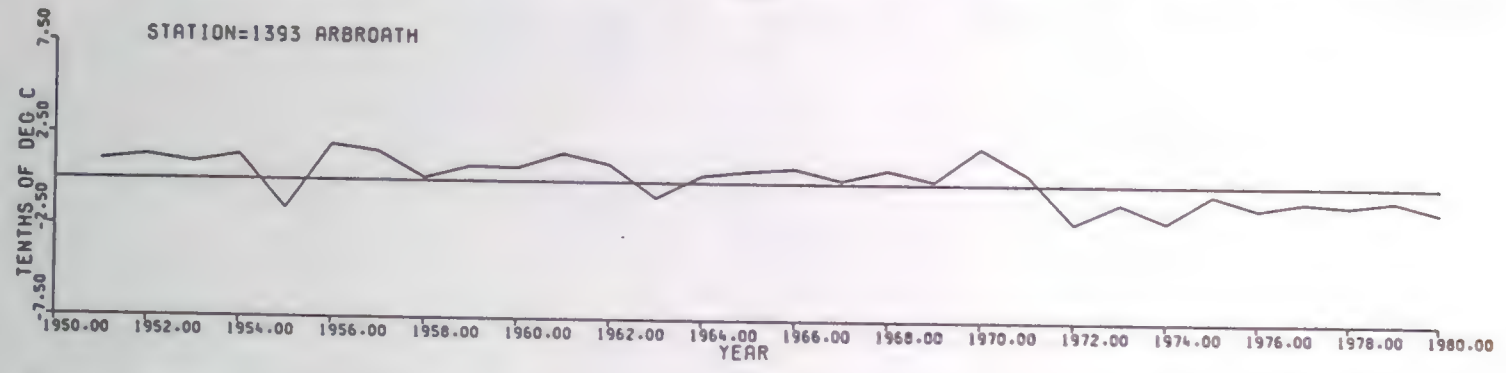


STATION=1393 ARBROATH



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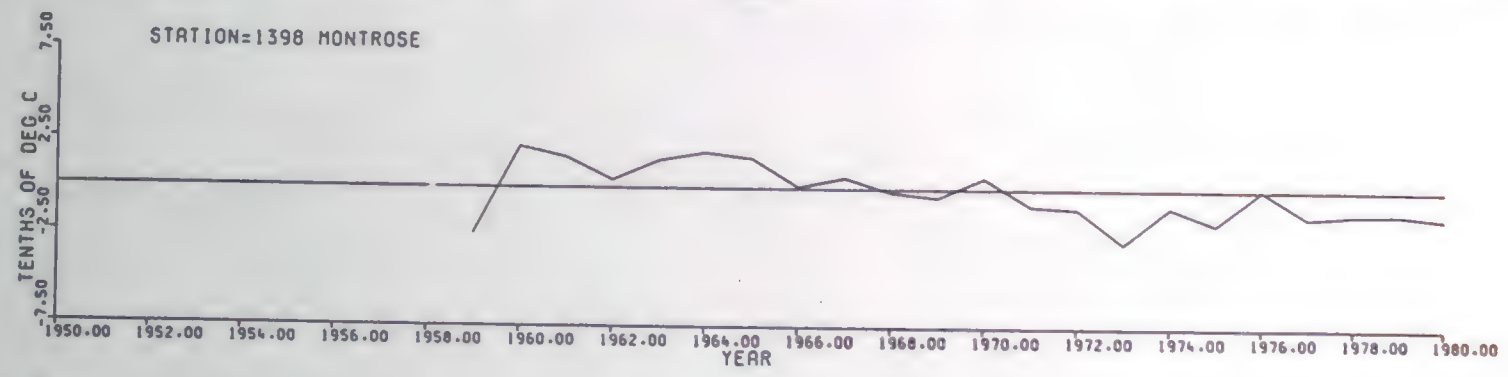
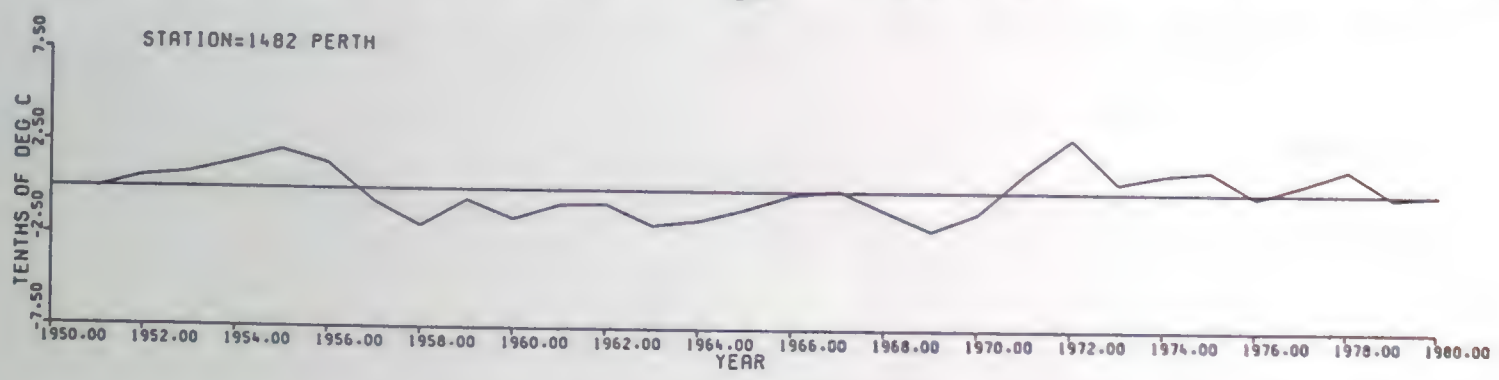
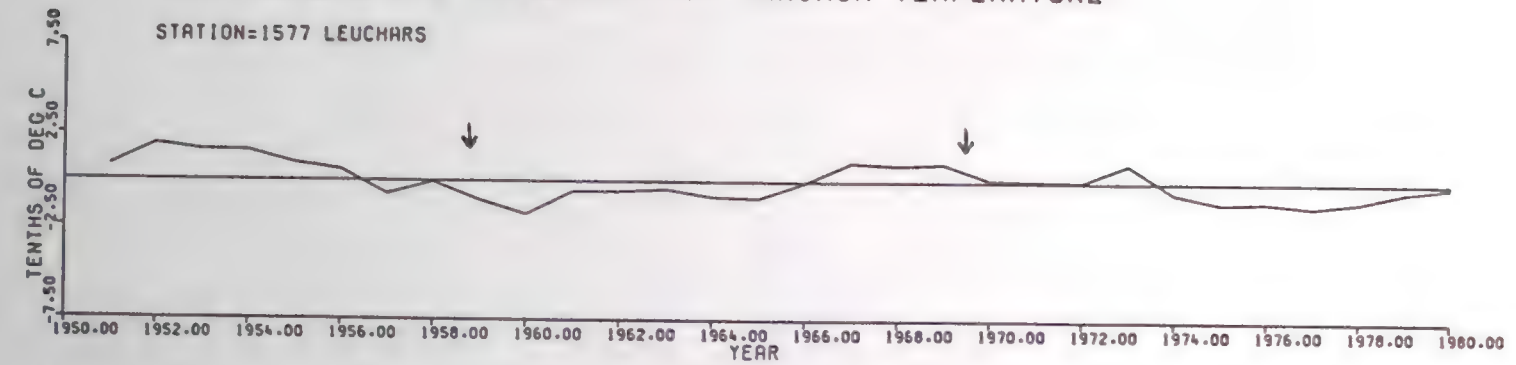
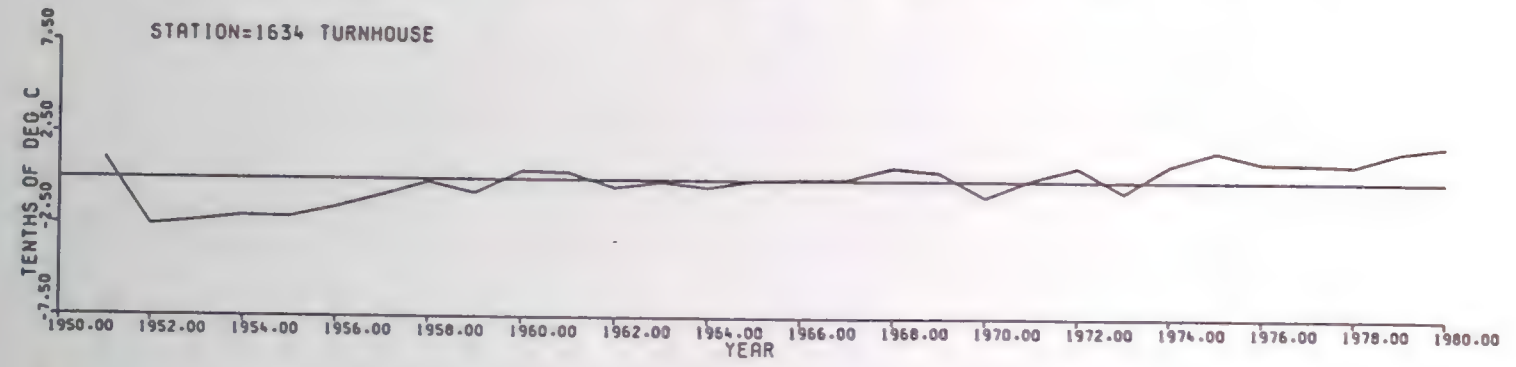


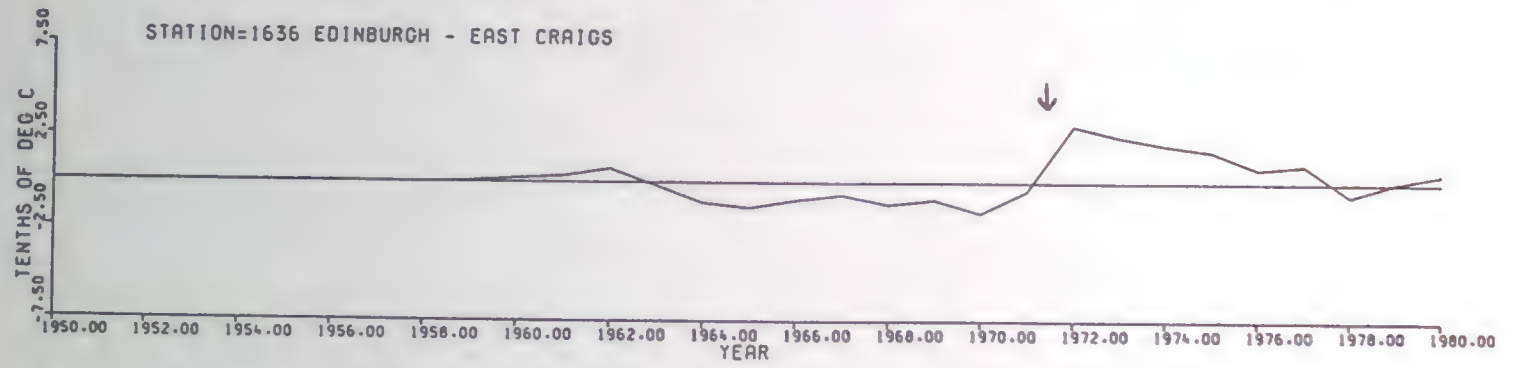
STATION=1482 PERTH

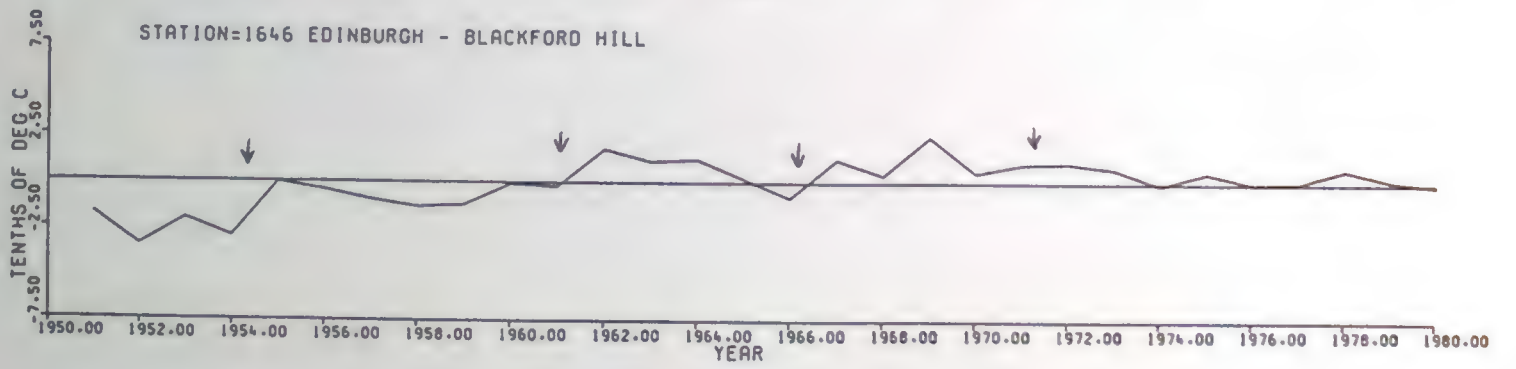


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE



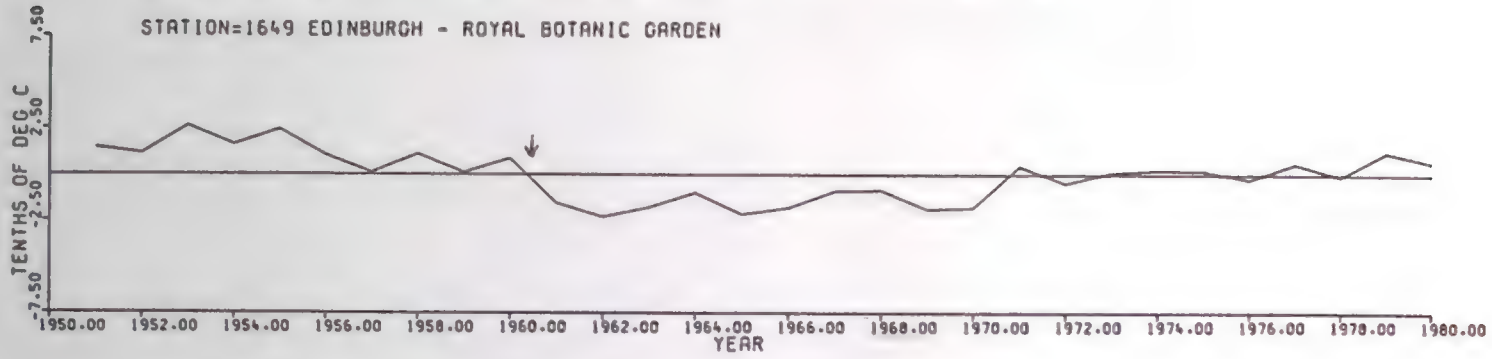




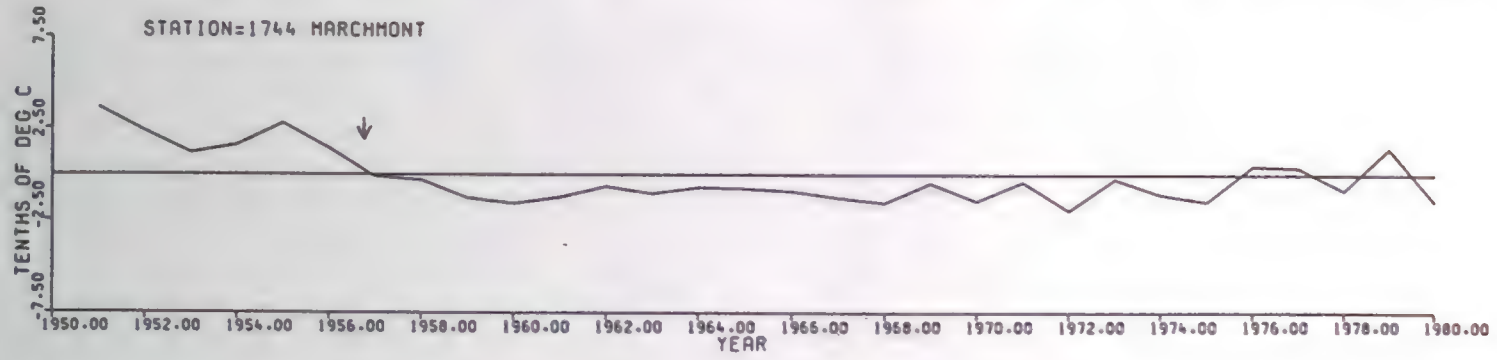


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

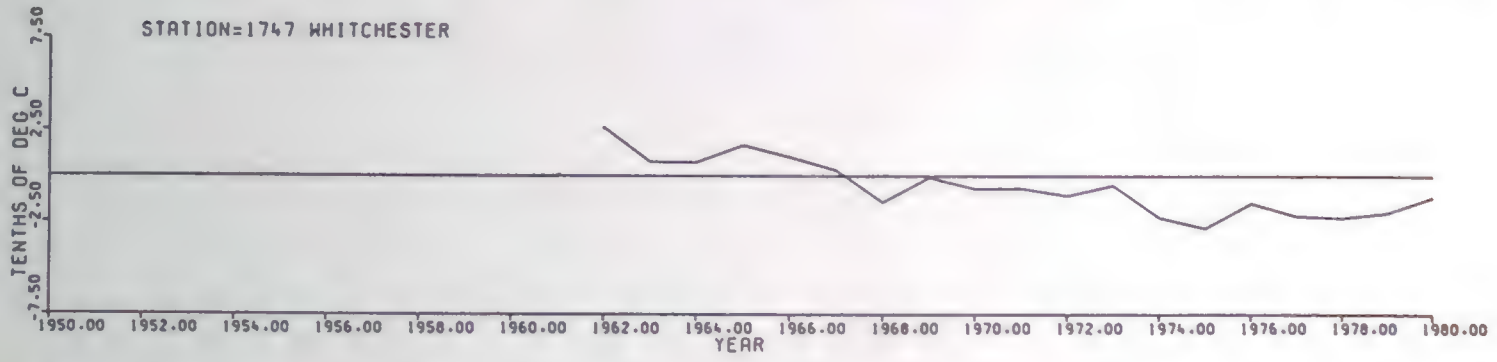
STATION=1649 EDINBURGH - ROYAL BOTANIC GARDEN



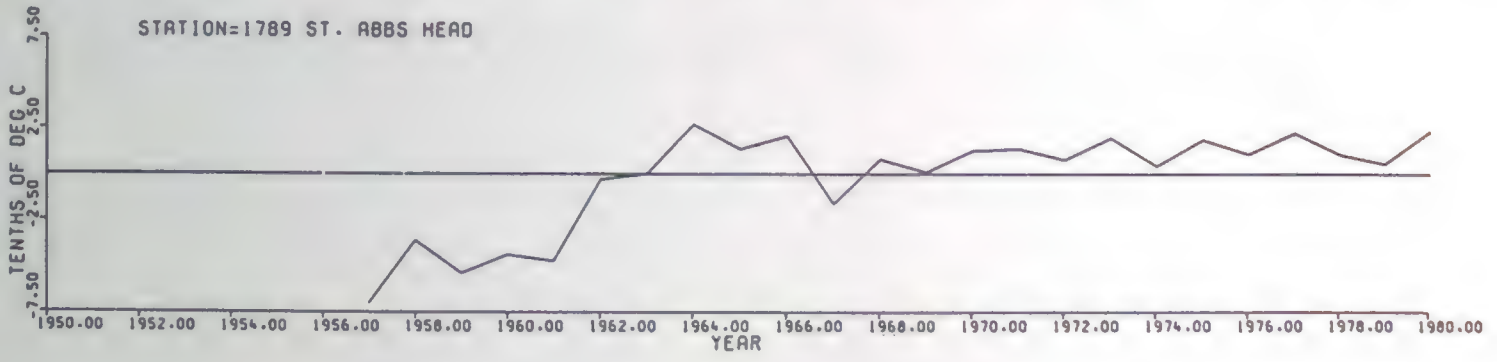
STATION=1744 MARCHMONT



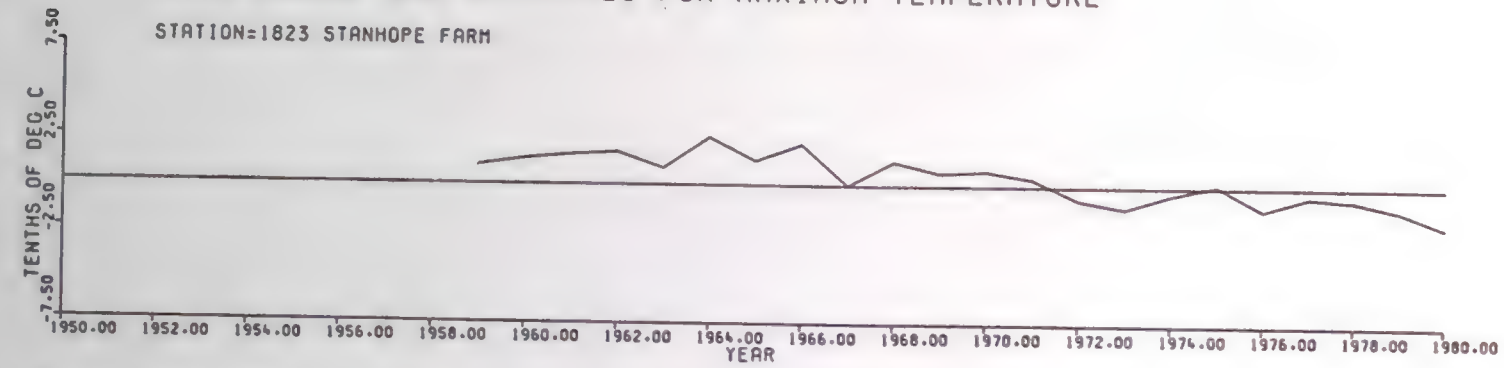
STATION=1747 WHITCHESTER

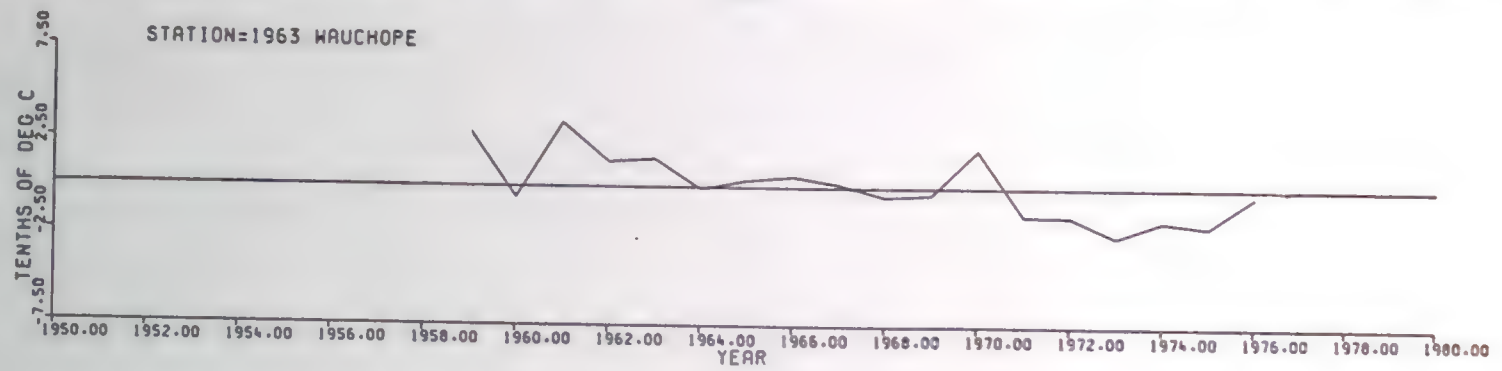


STATION=1789 ST. ABBS HEAD

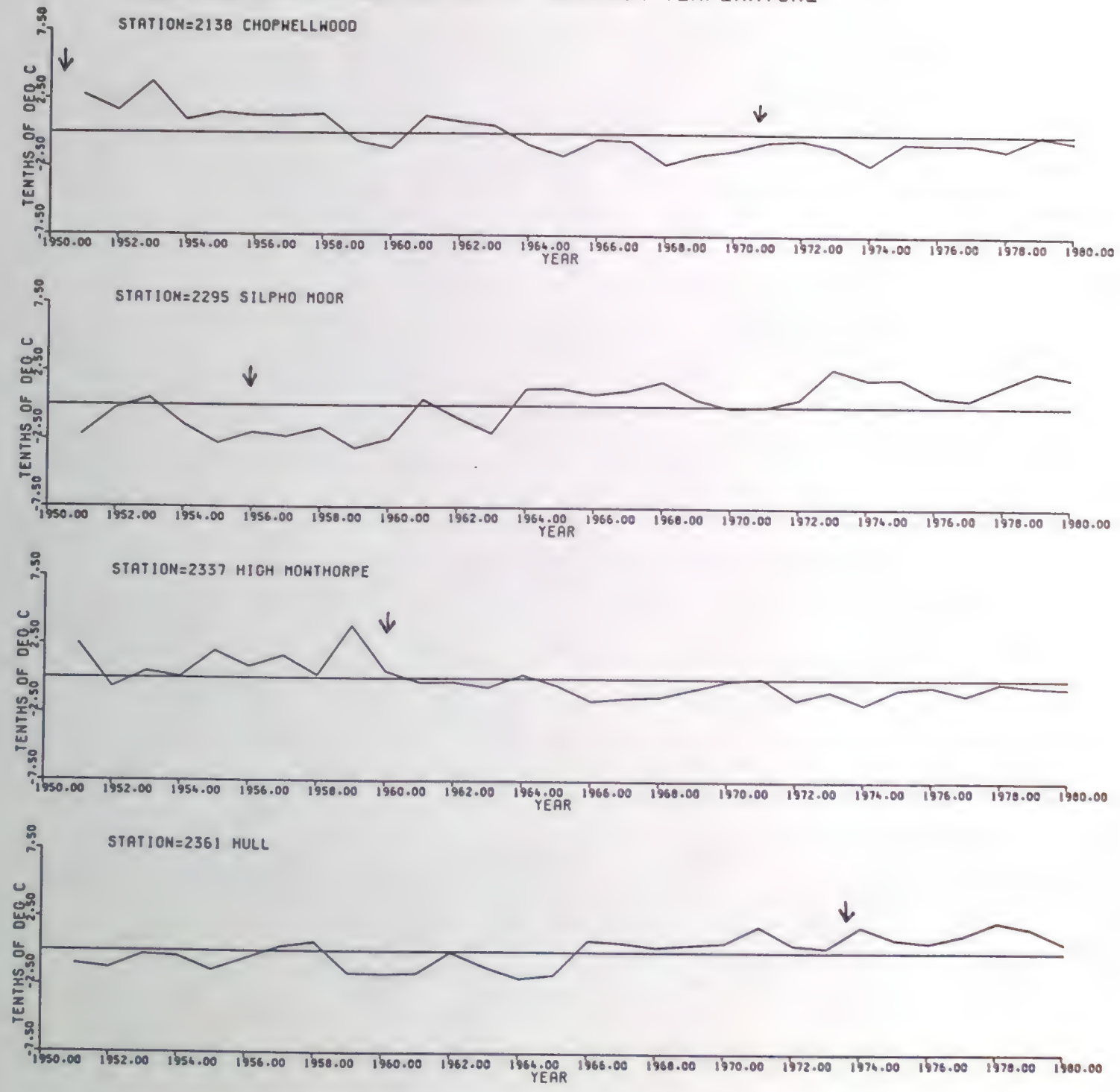


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE



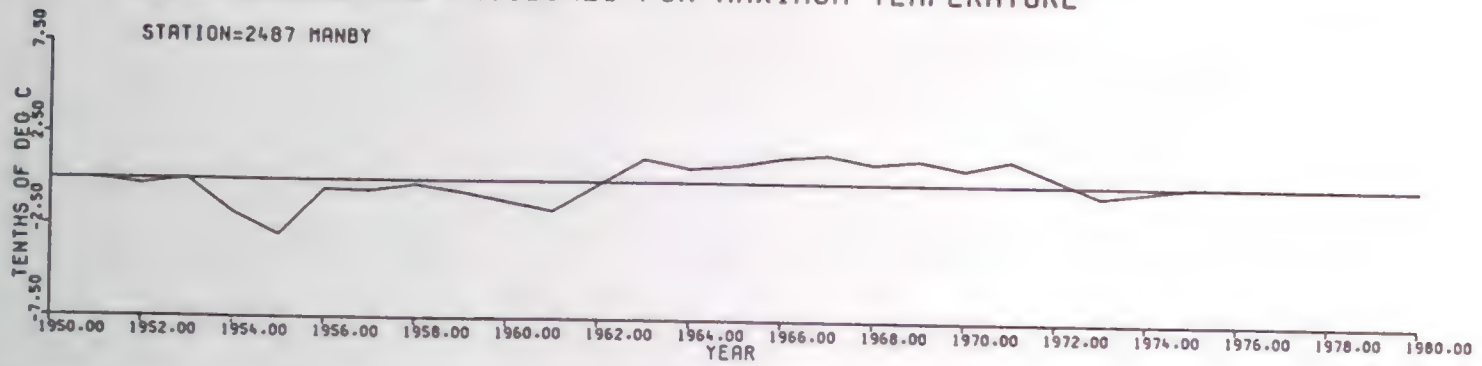


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

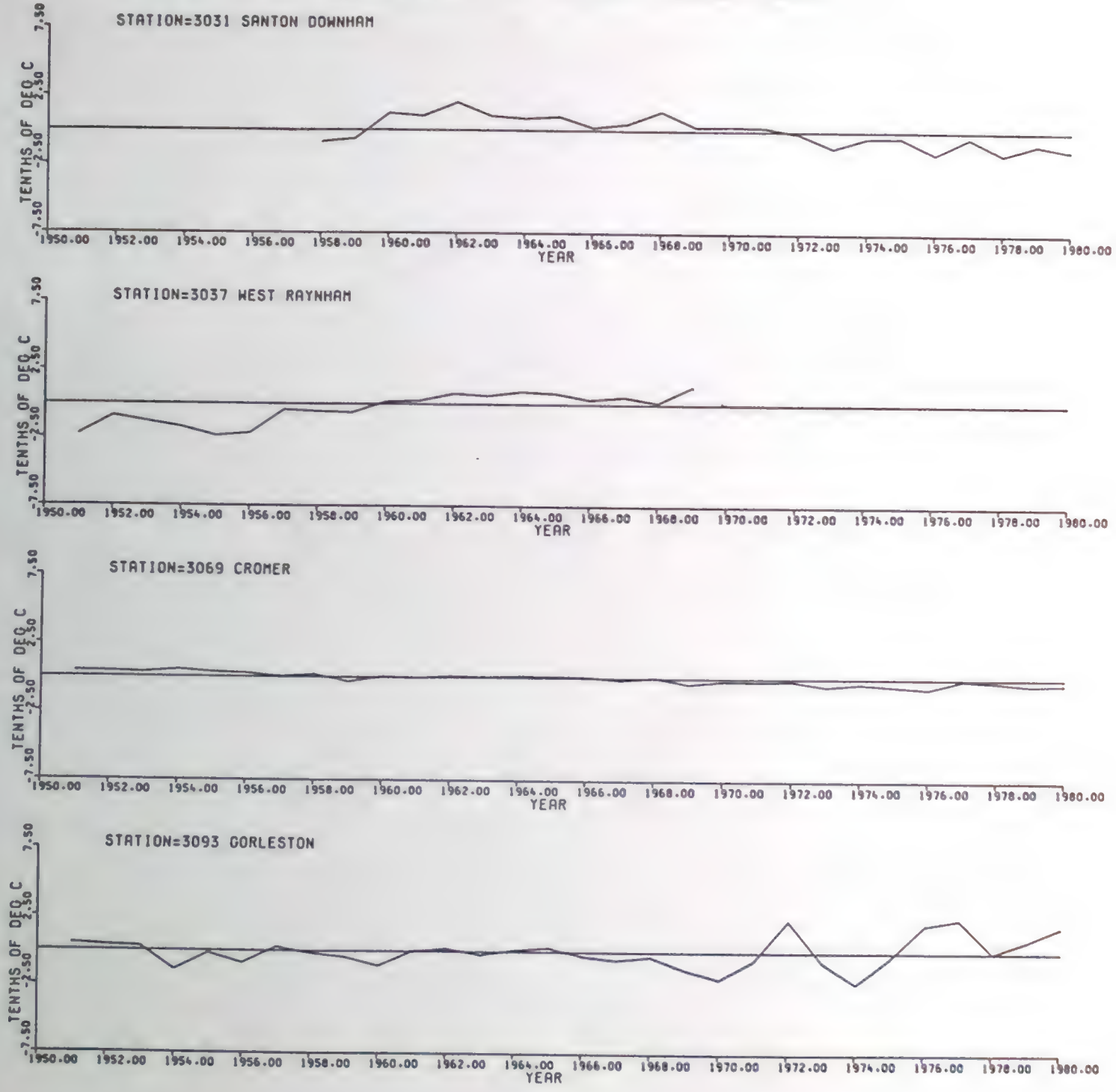


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

STATION=2487 MANBY



MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE



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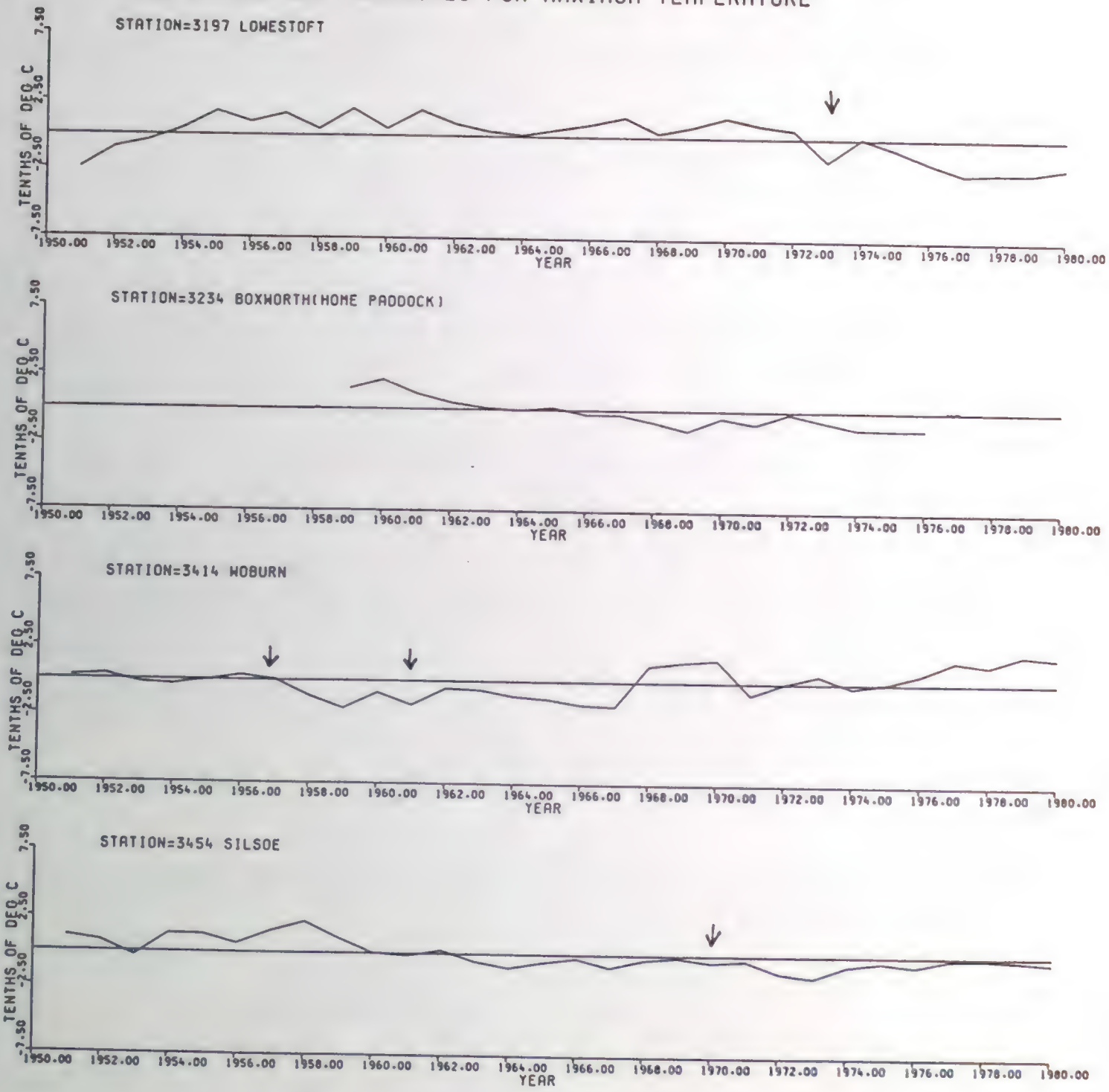

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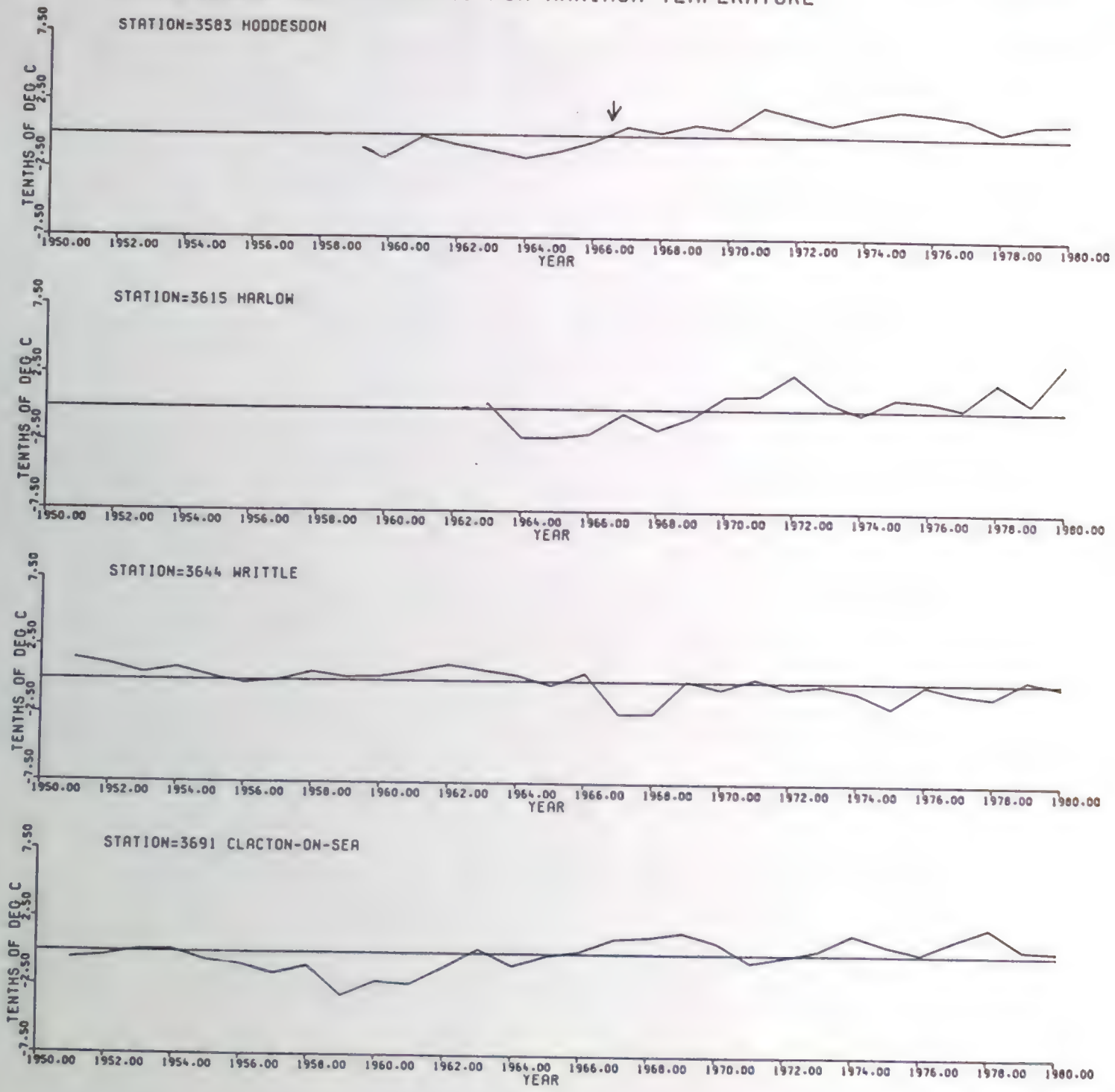

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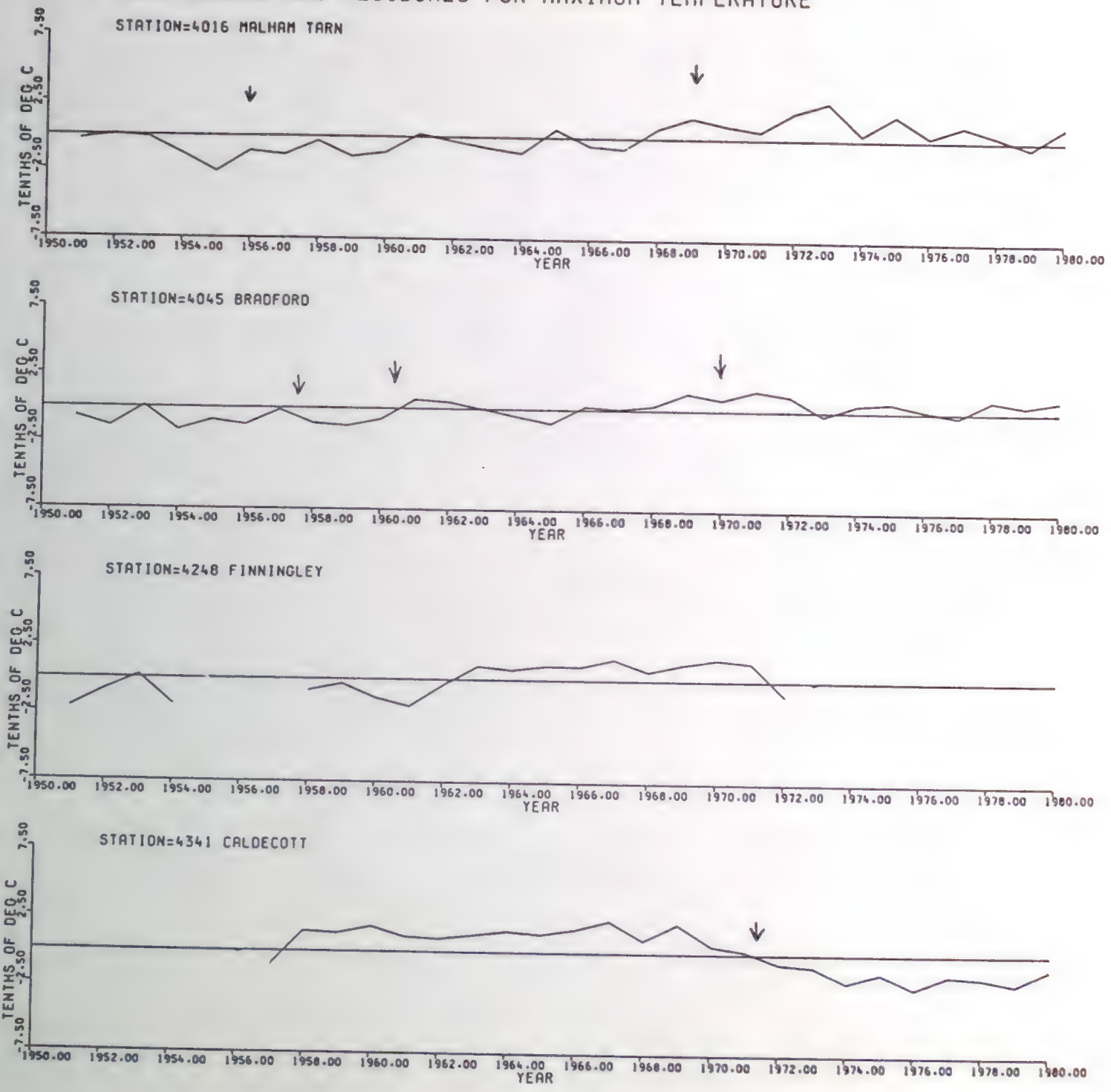

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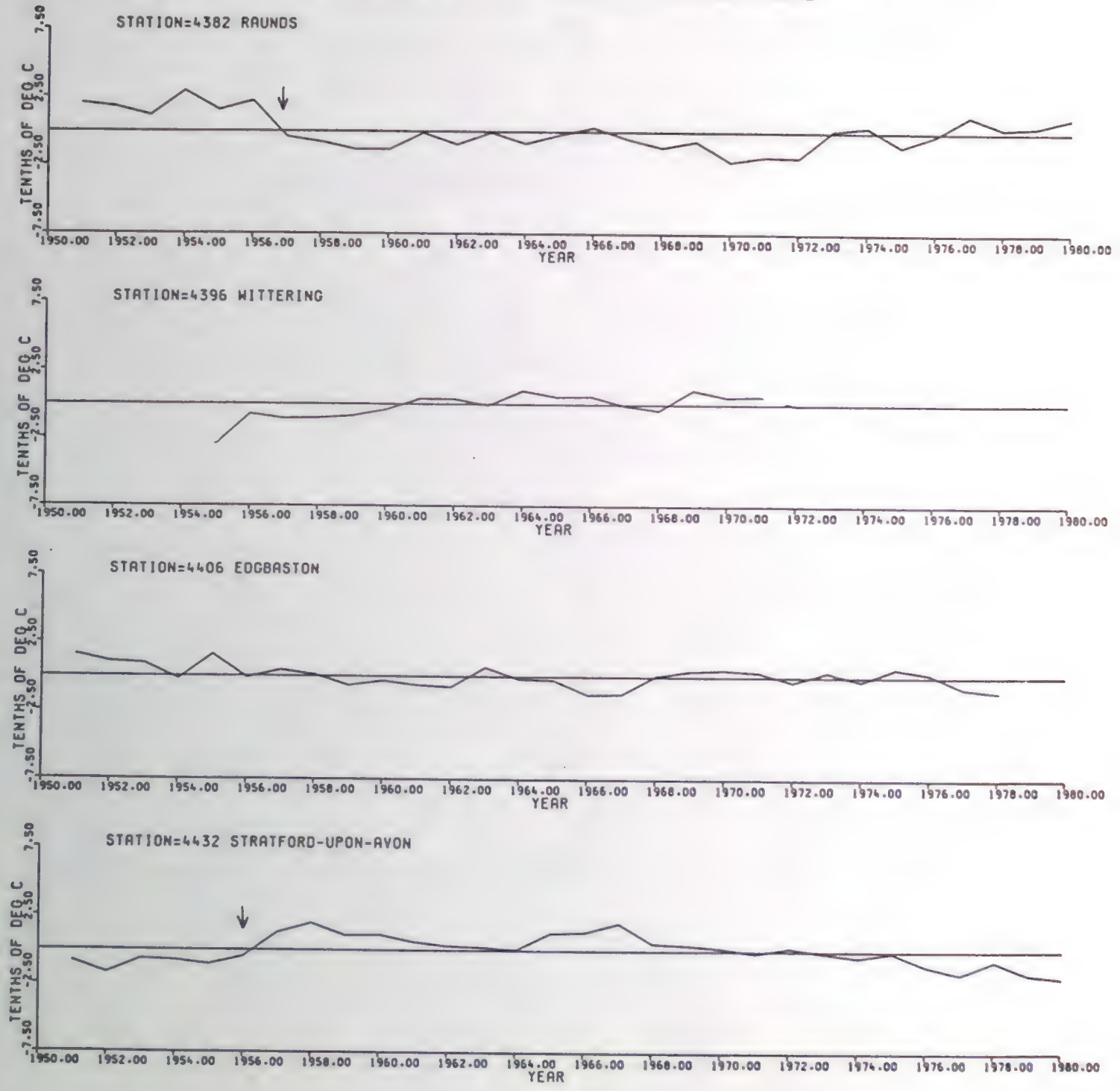

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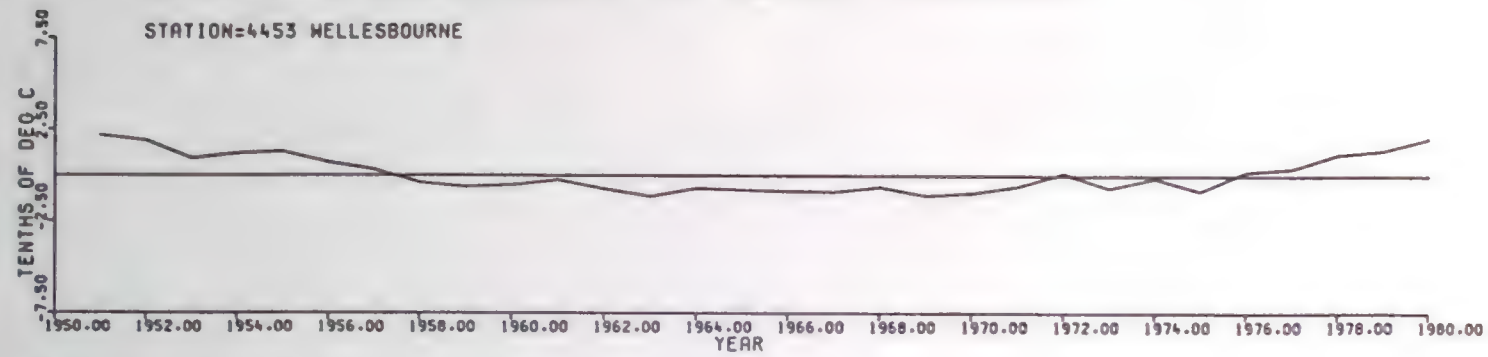

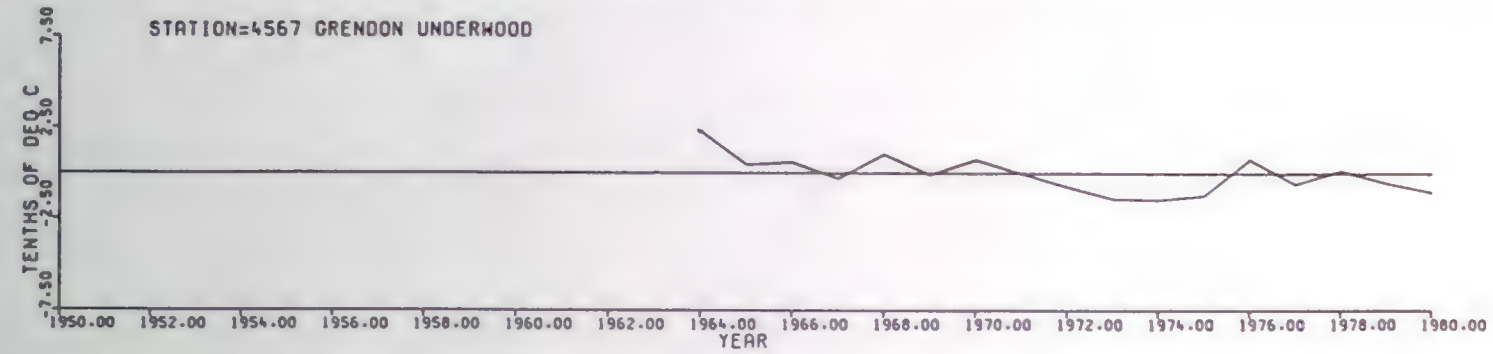

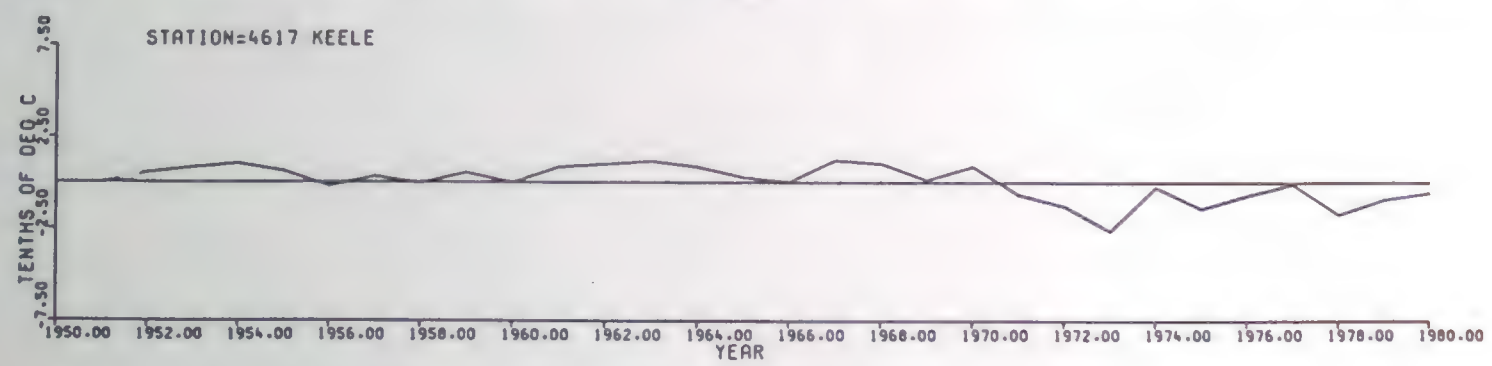

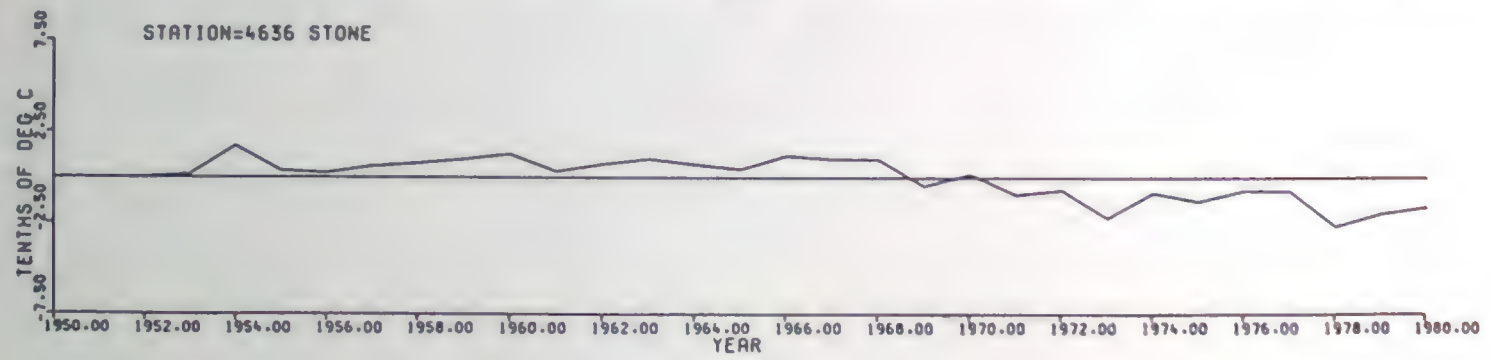

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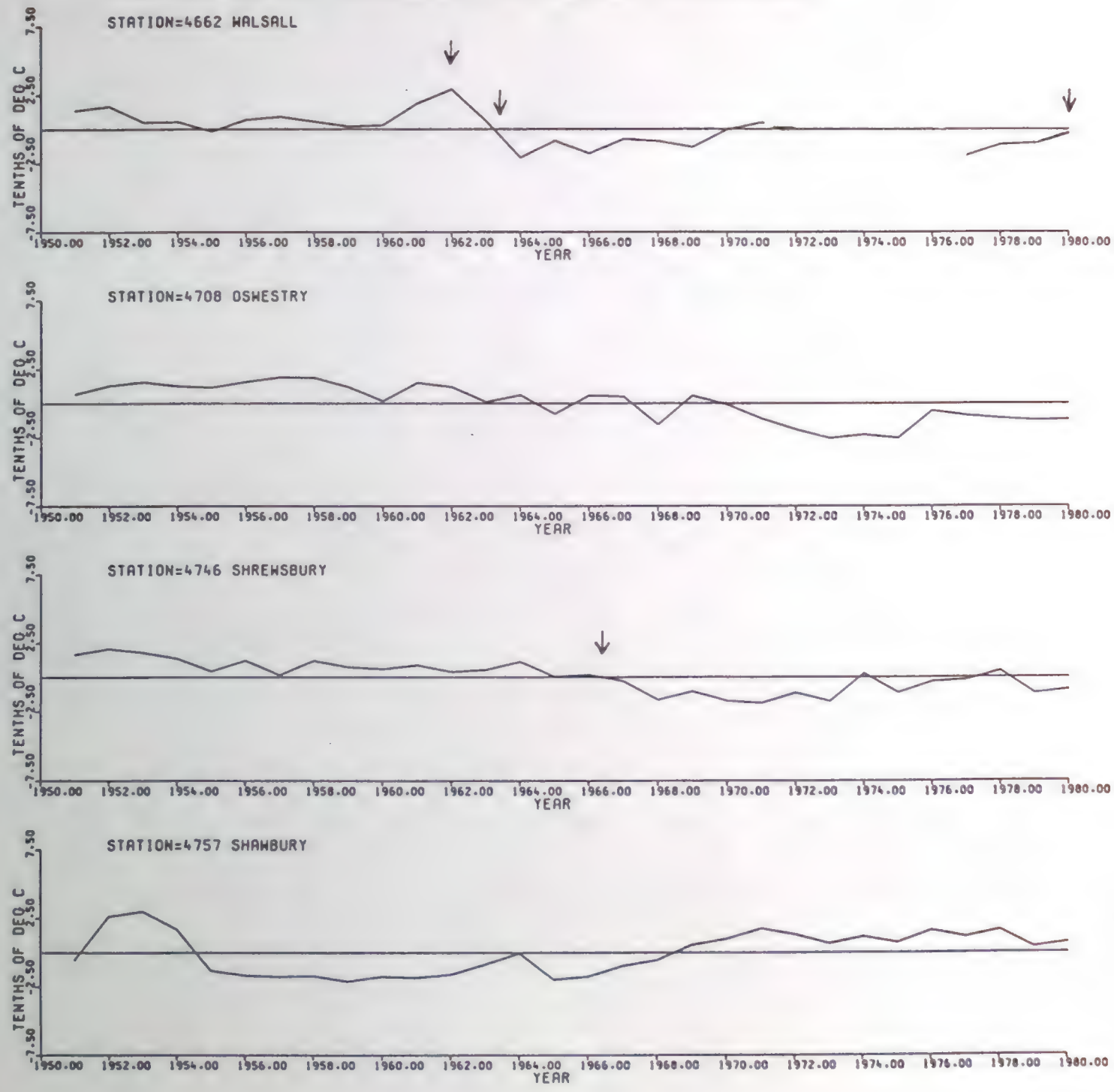
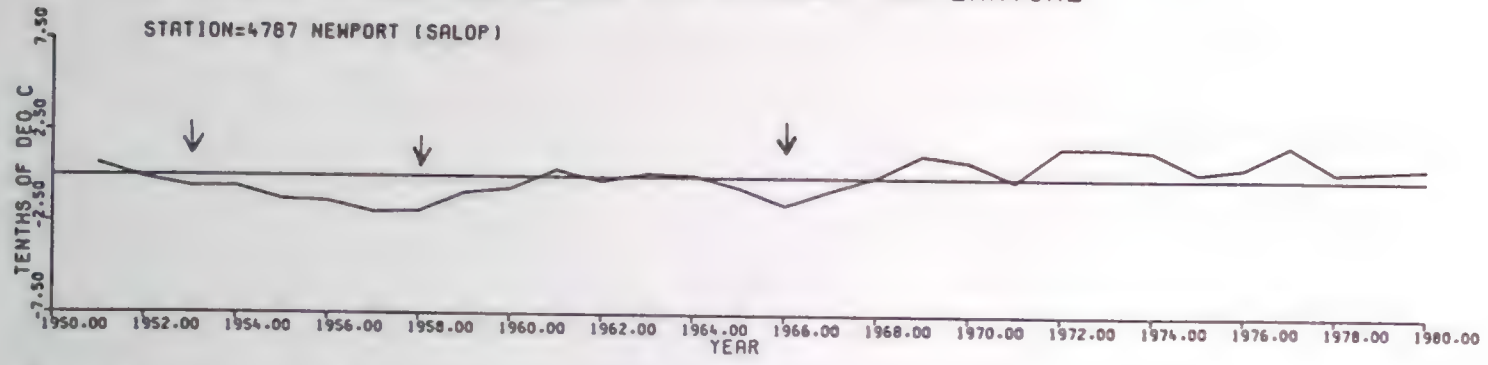
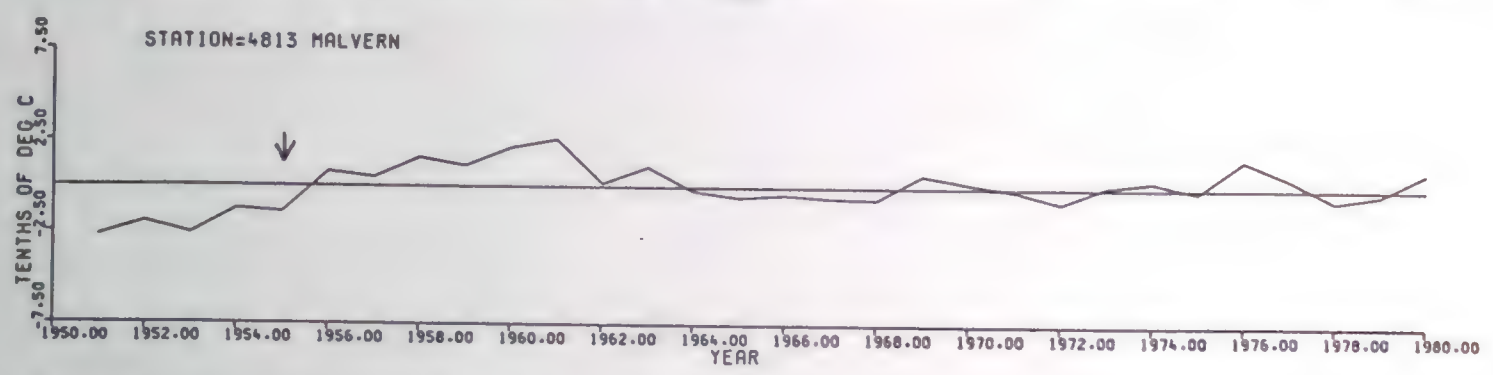
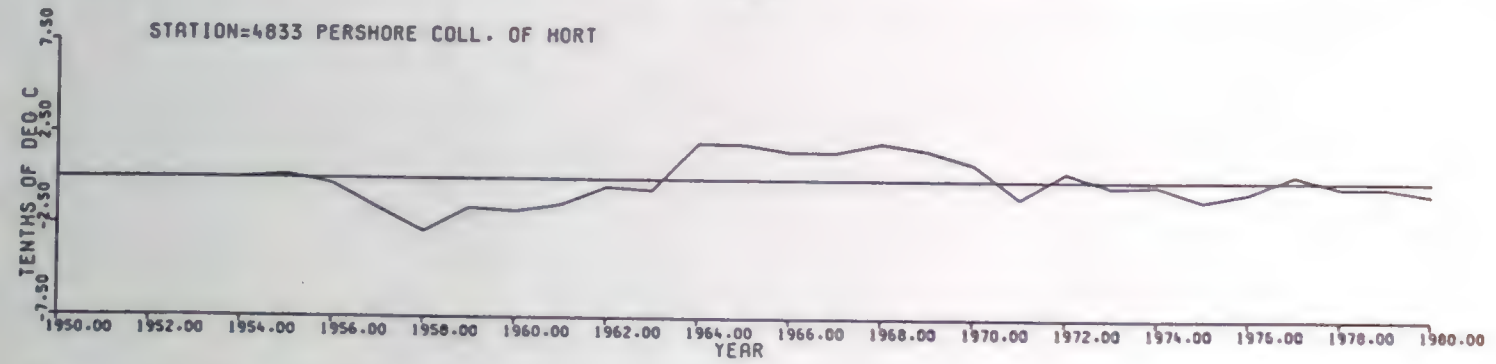
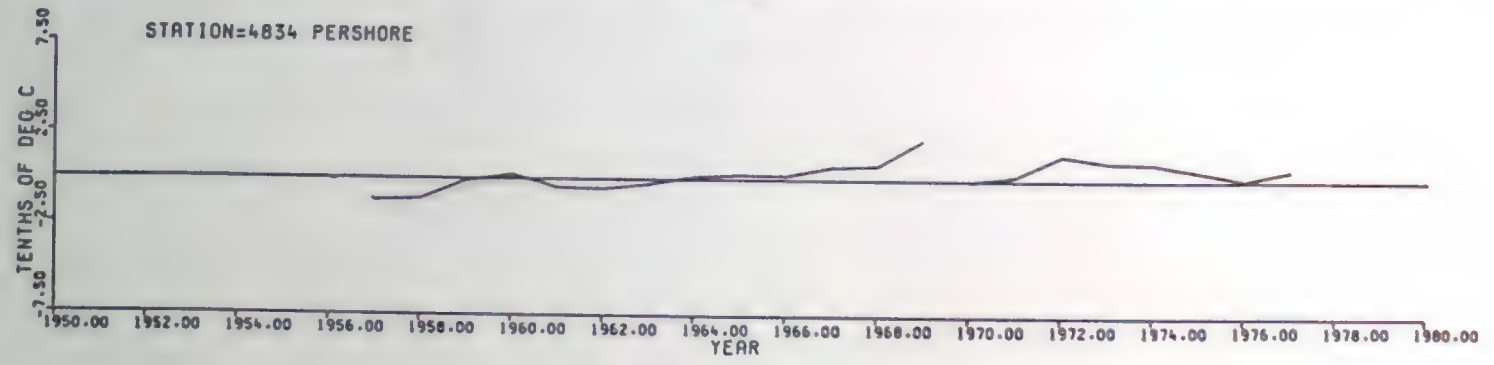


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE









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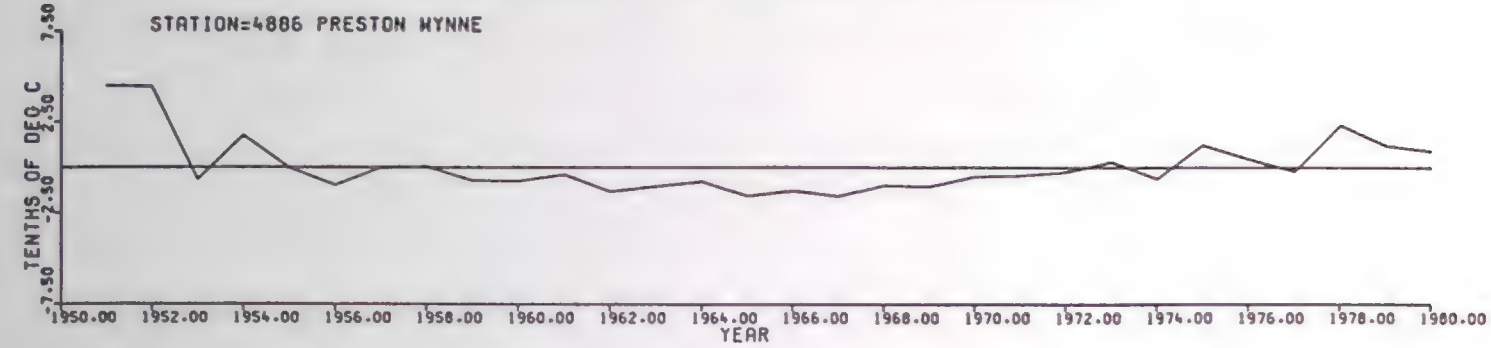
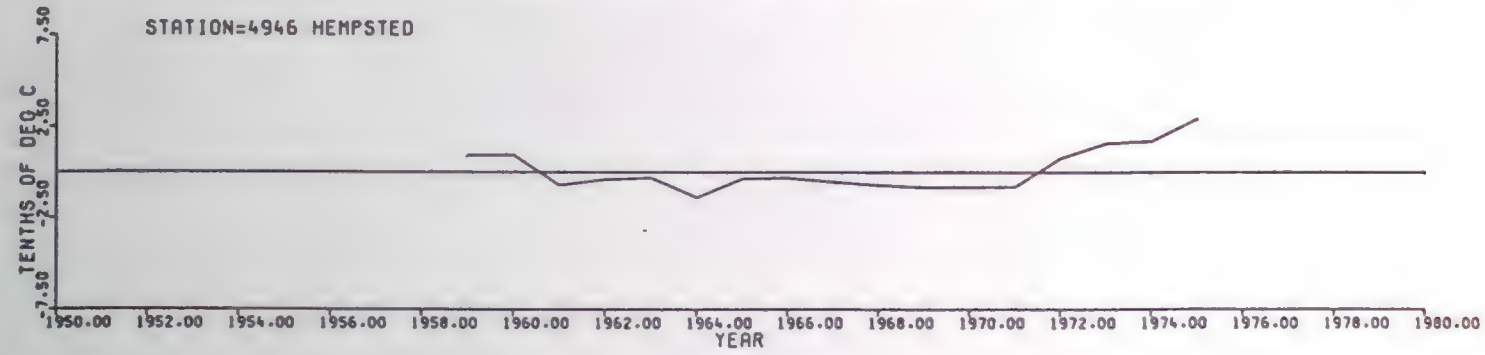
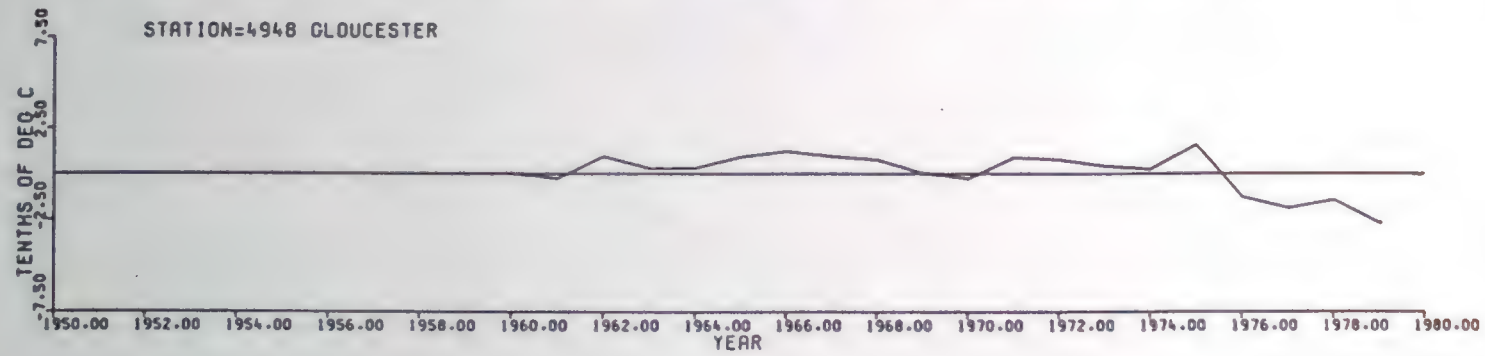
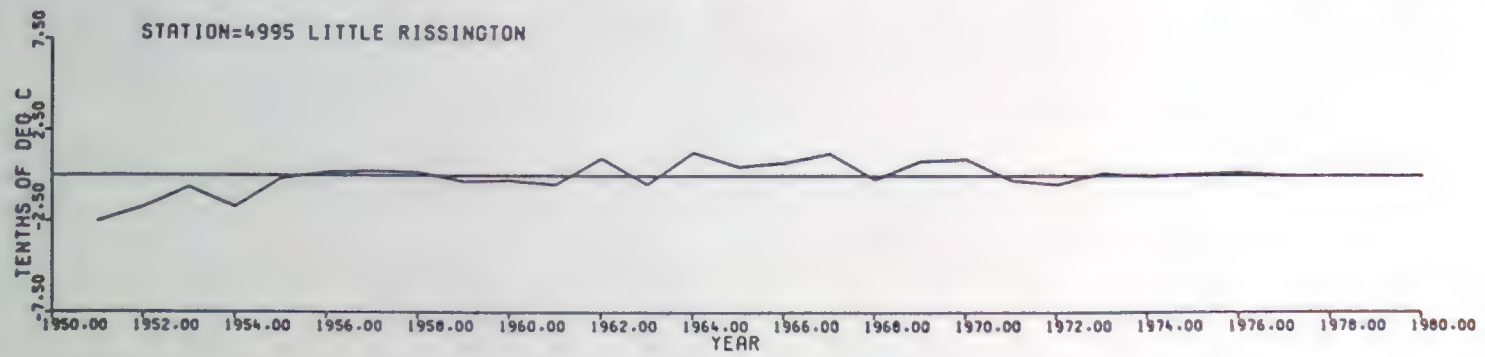
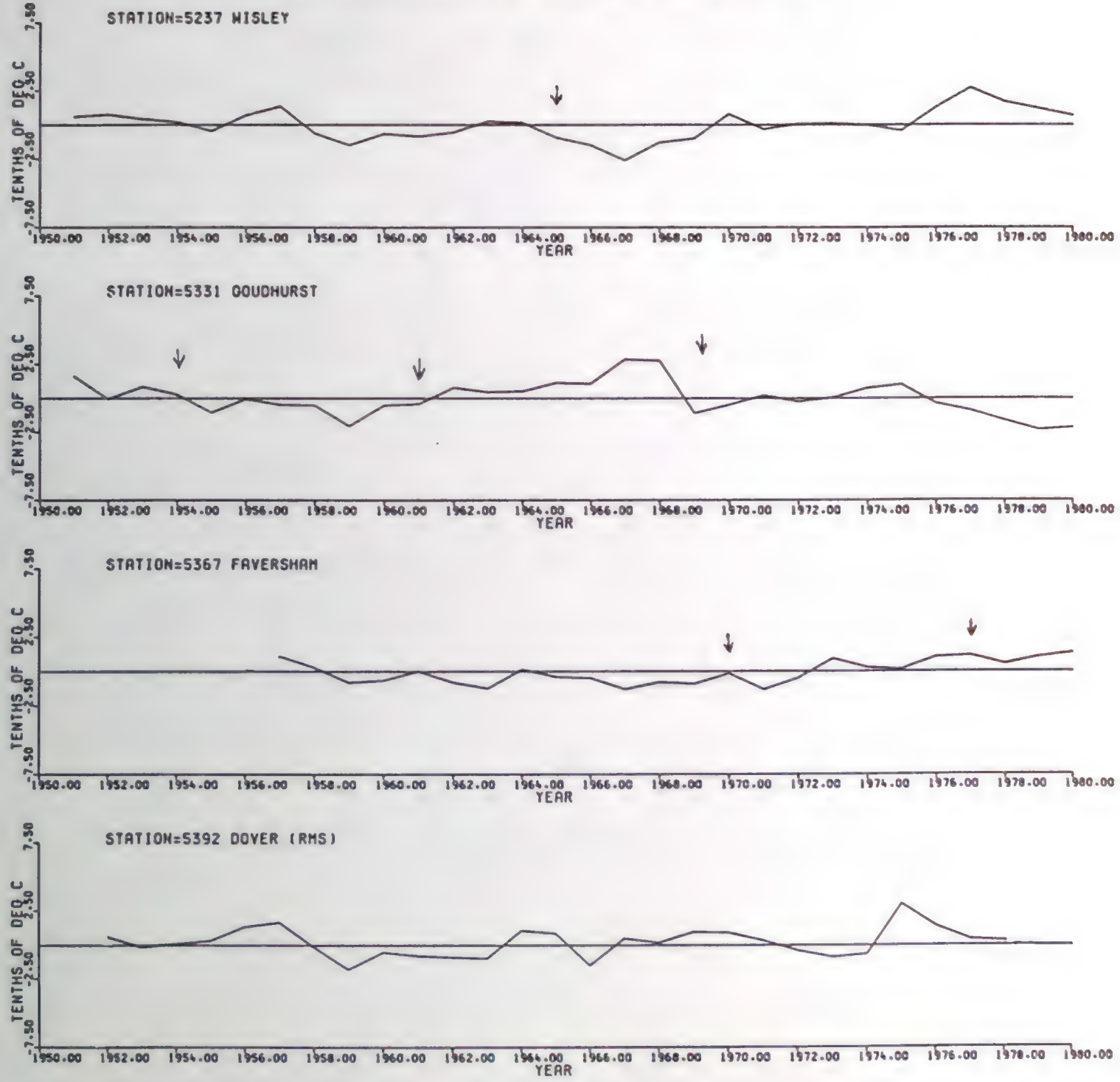








MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE



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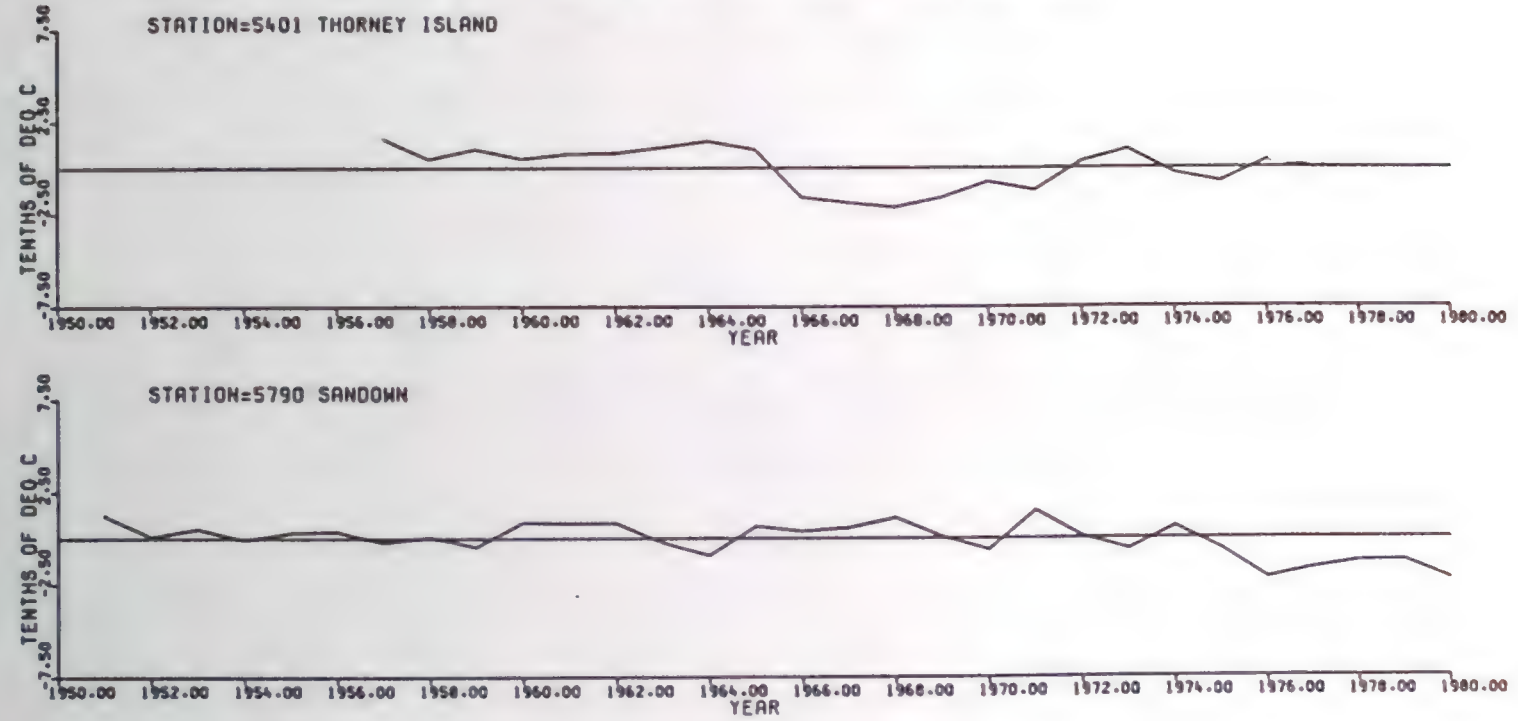

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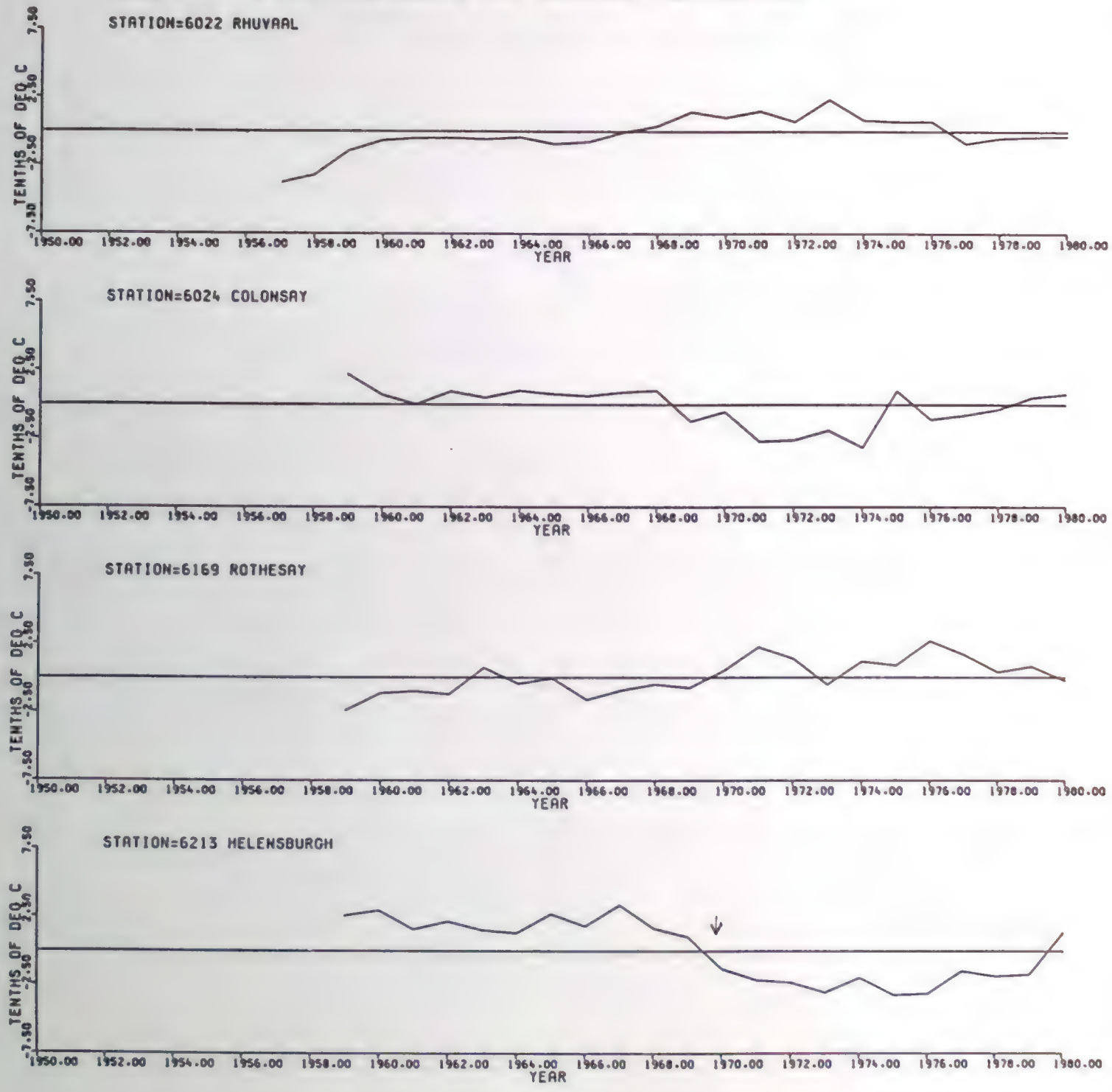

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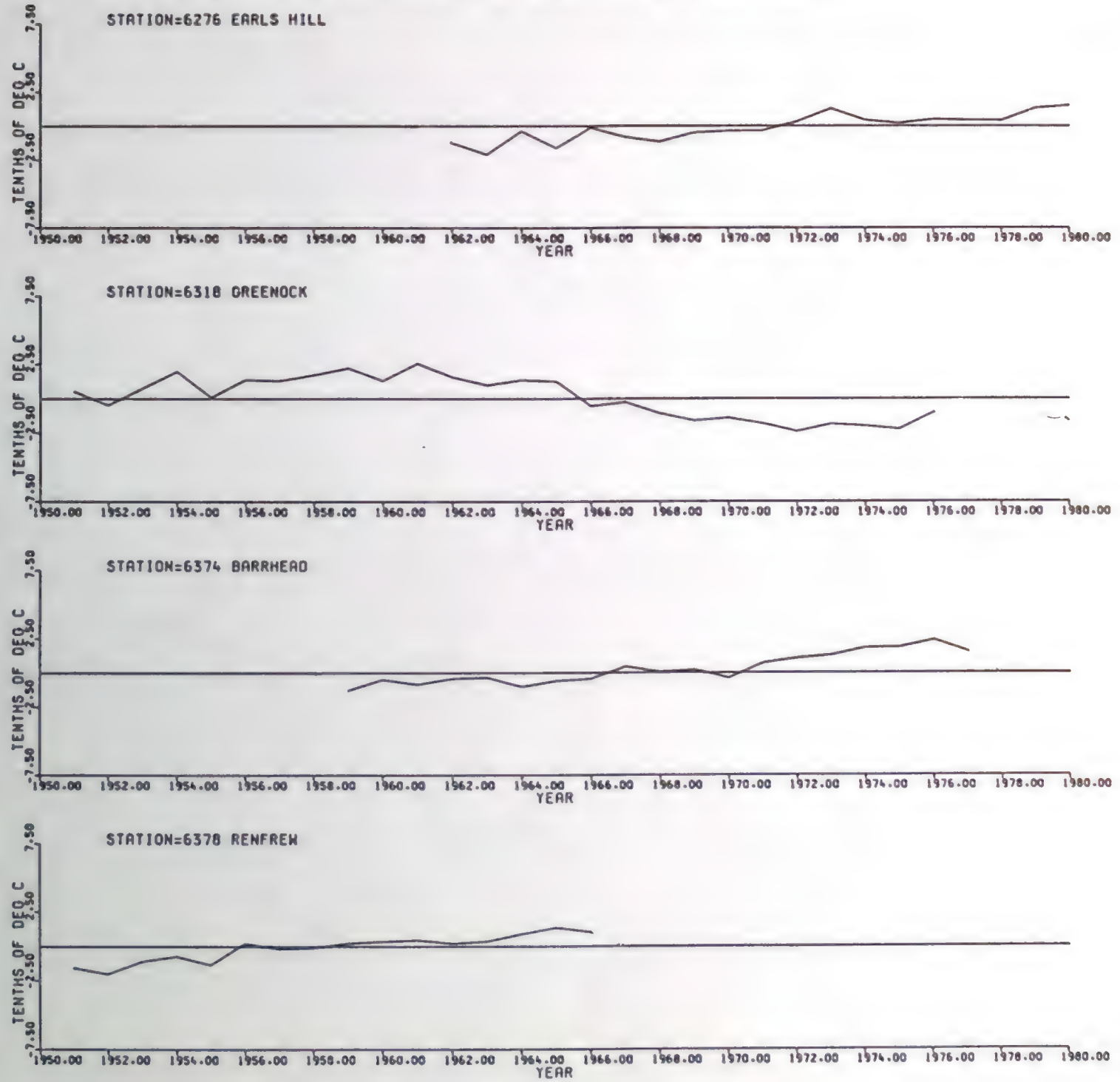
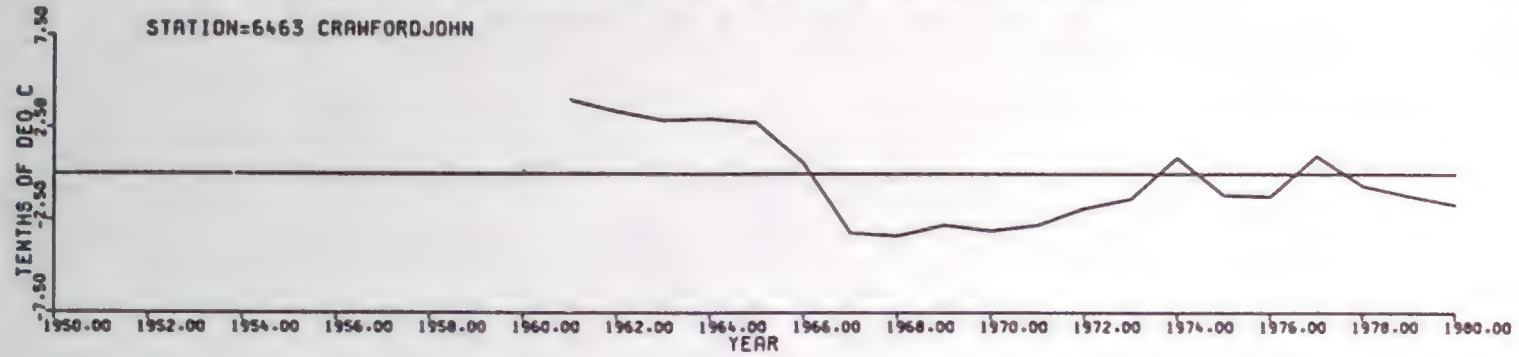
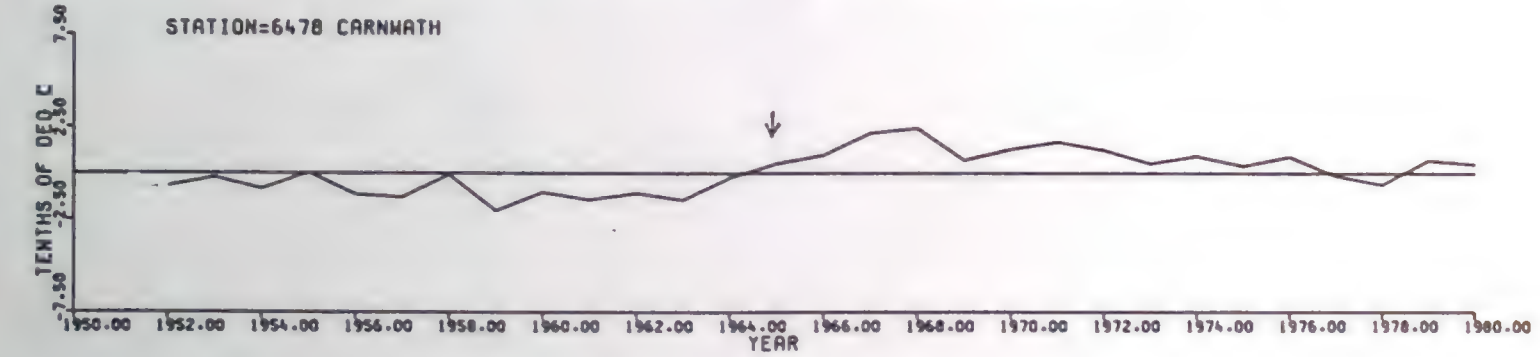
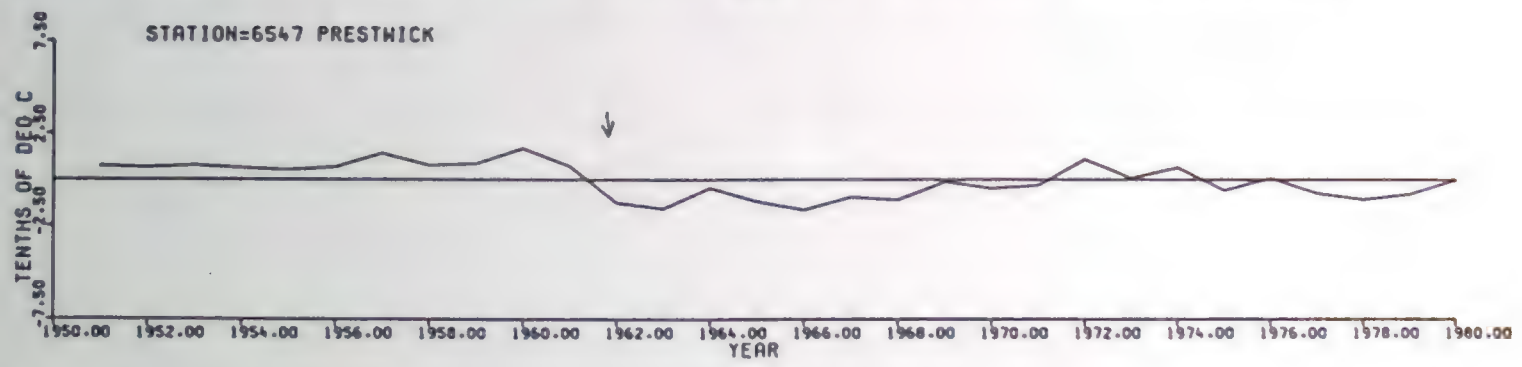
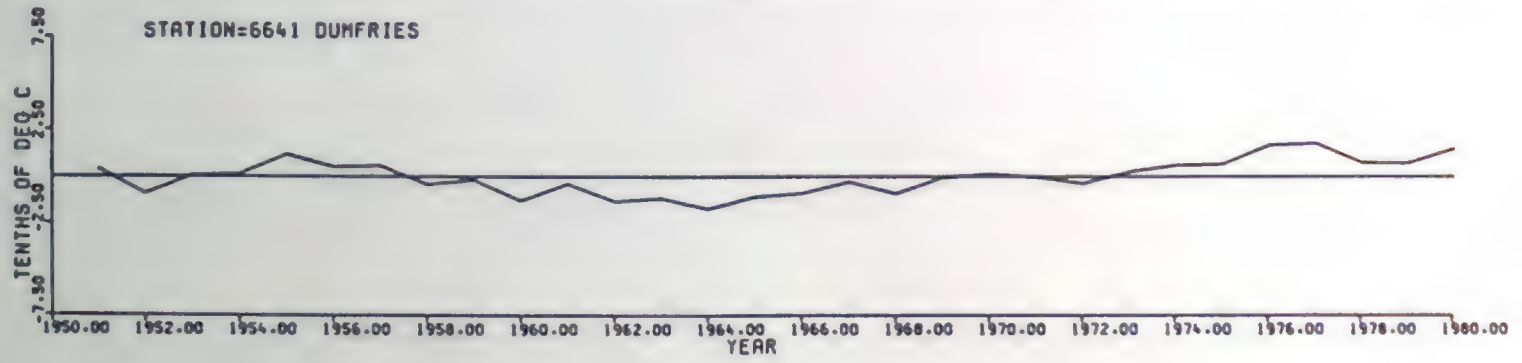


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

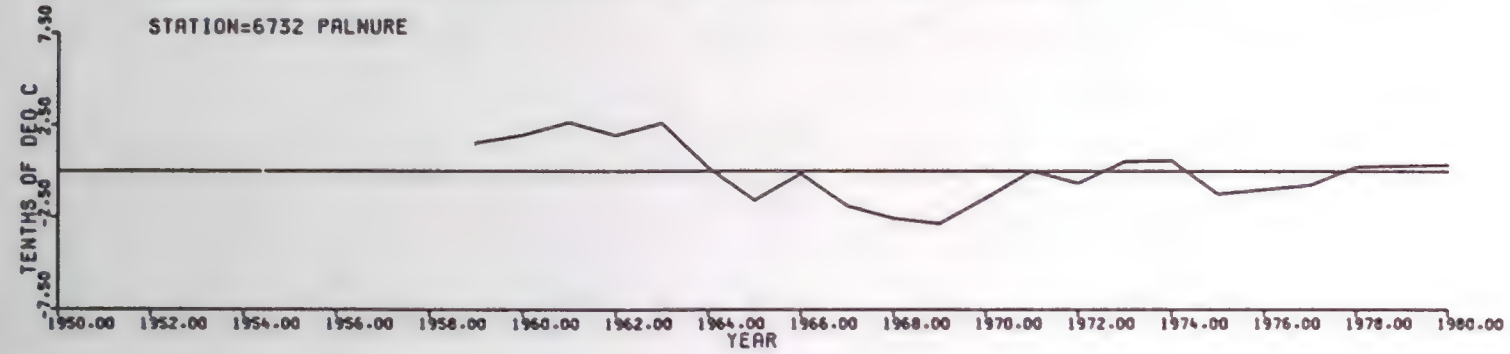


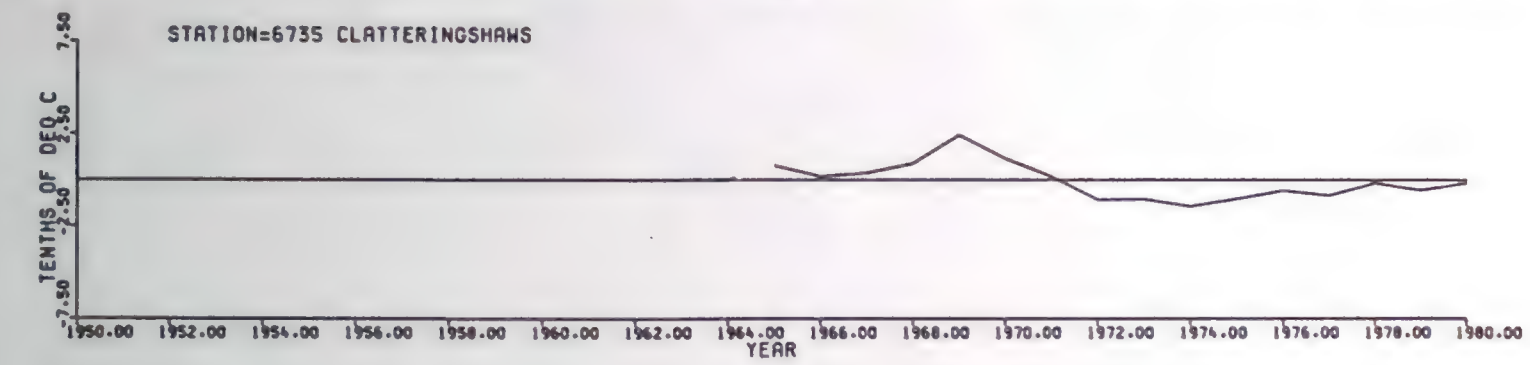


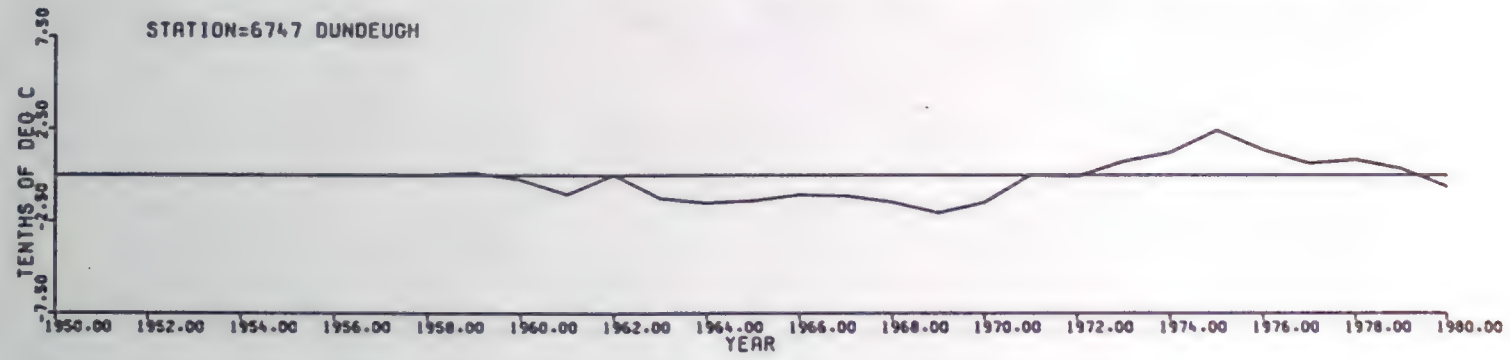


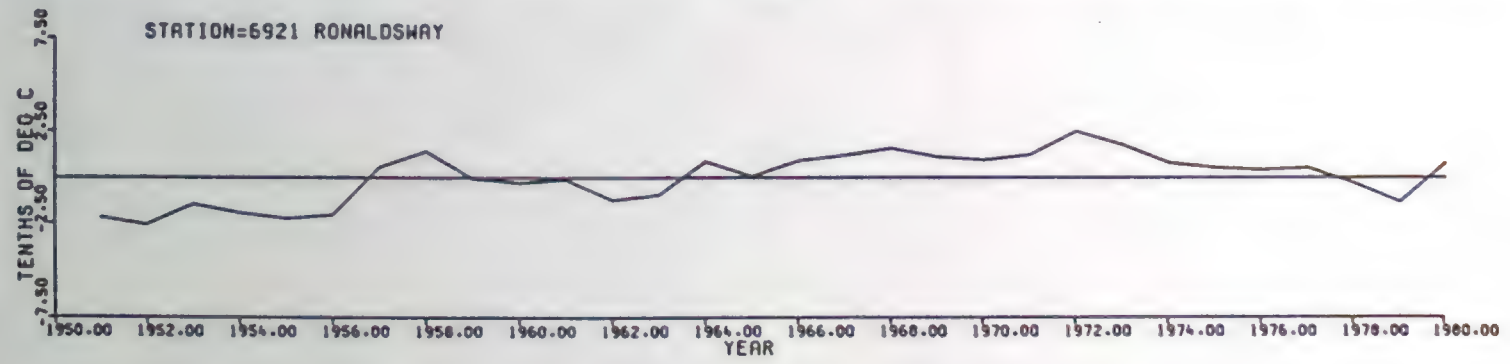


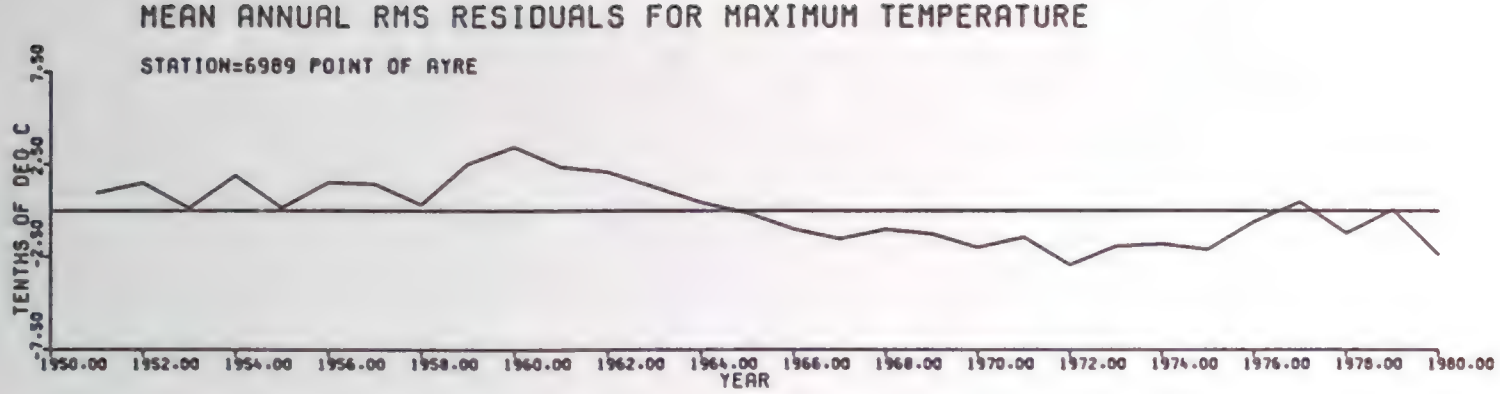
MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE










MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE
STATION=6989 POINT OF AYRE
TENTHS OF DEG C
7.50
2.50
-2.50
-7.50
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
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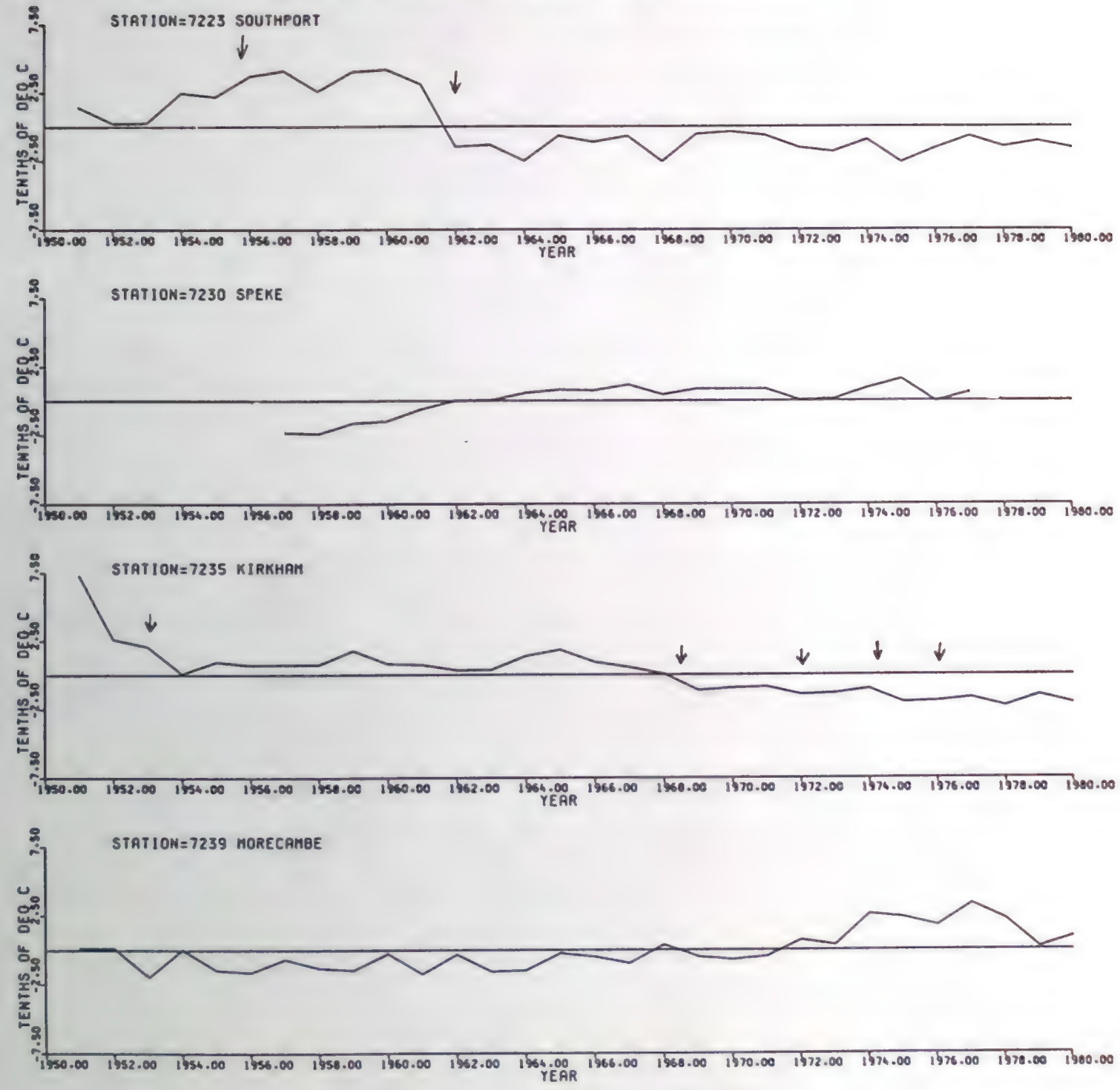
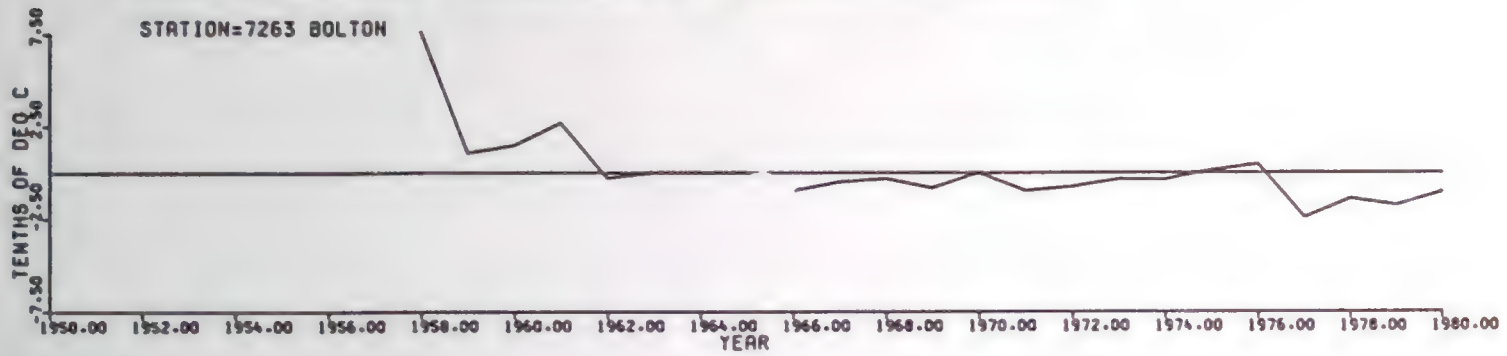
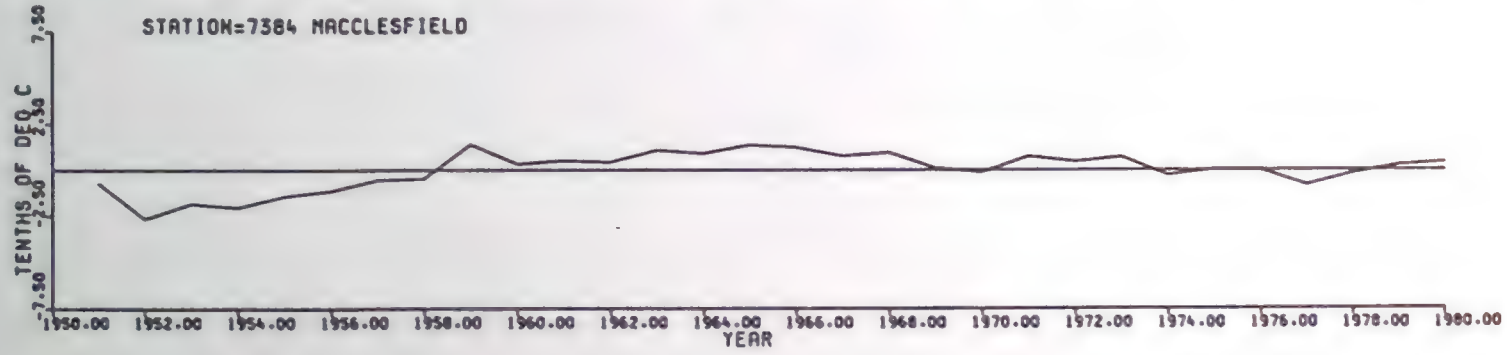
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

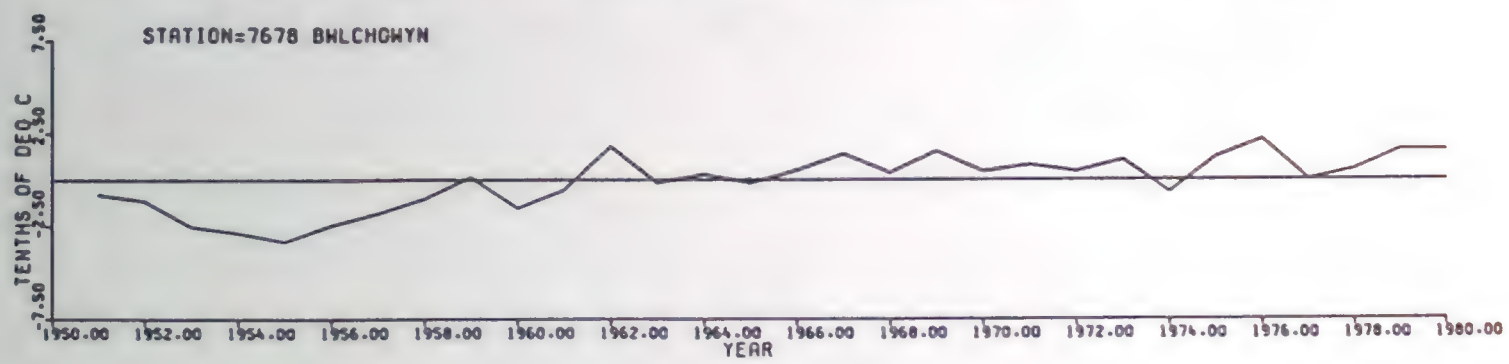
MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

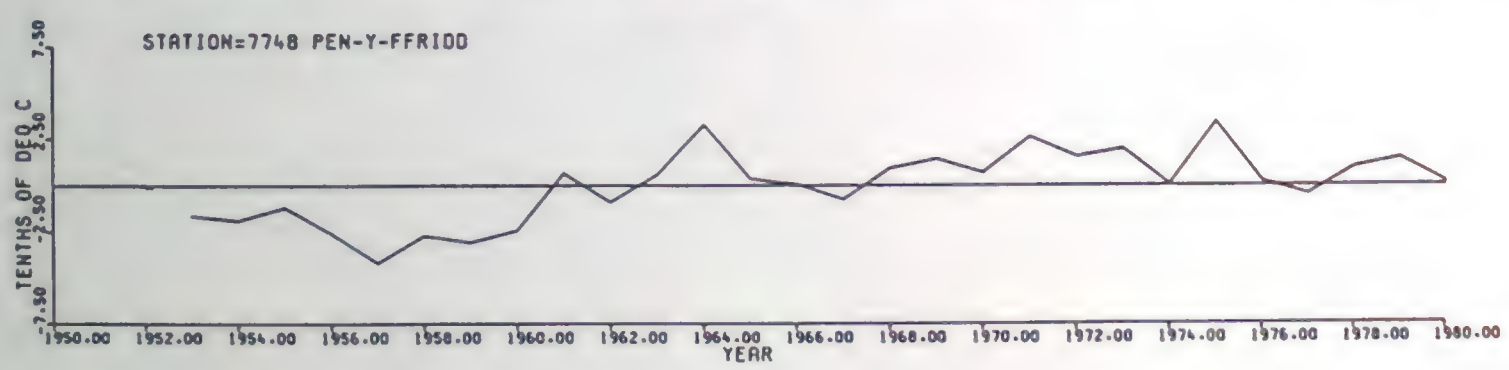


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

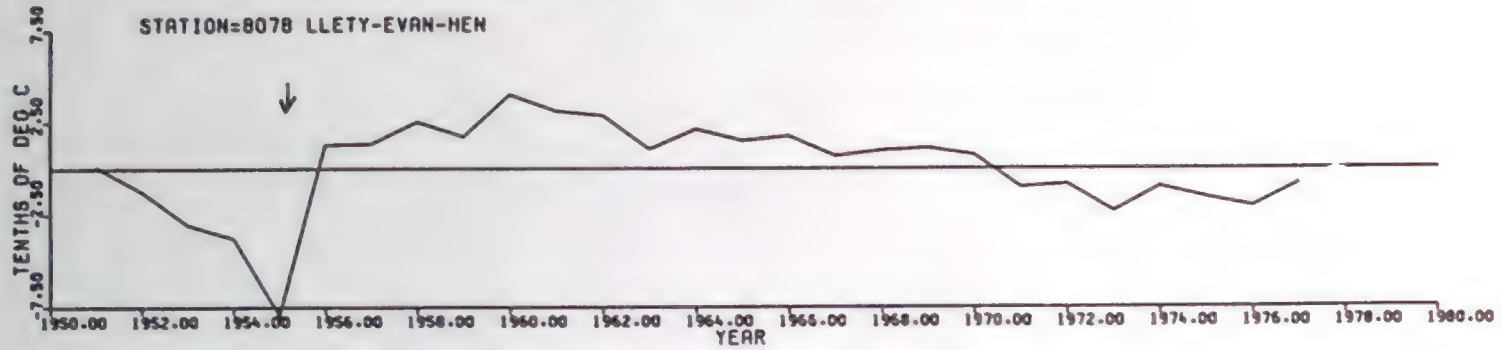


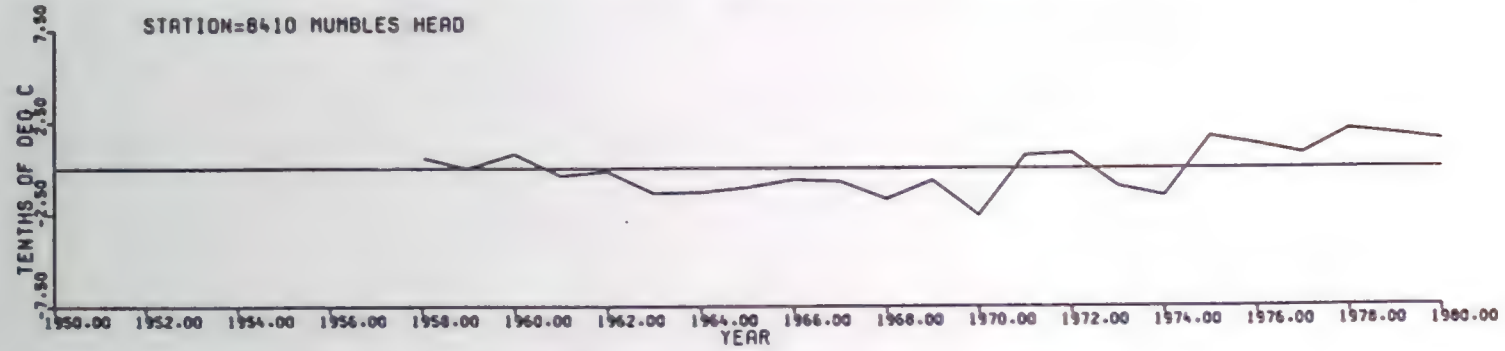


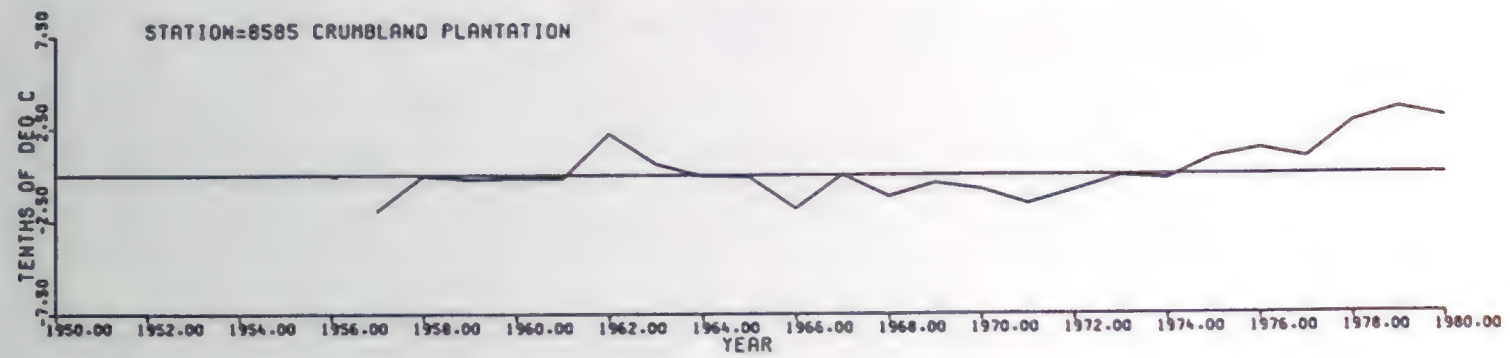


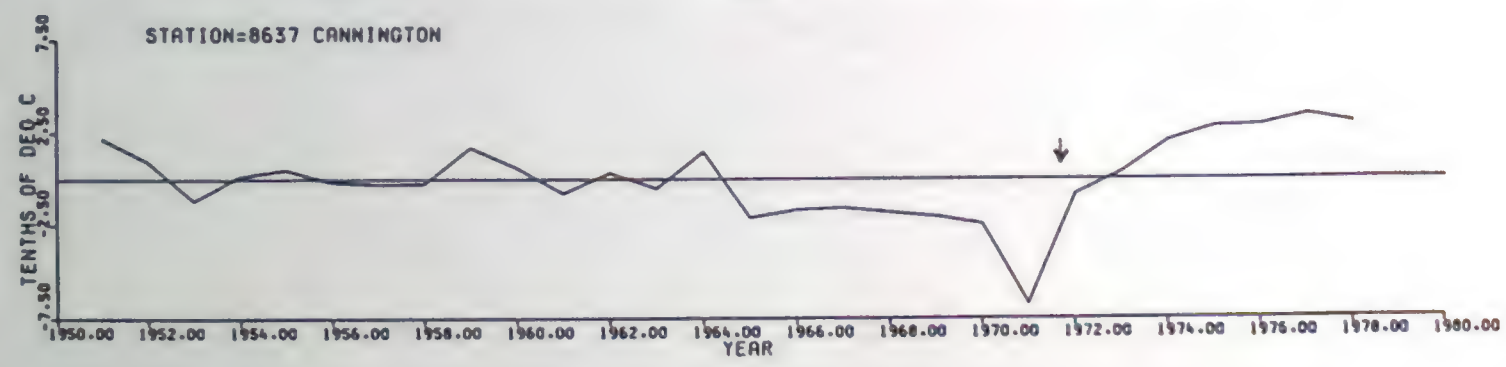


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

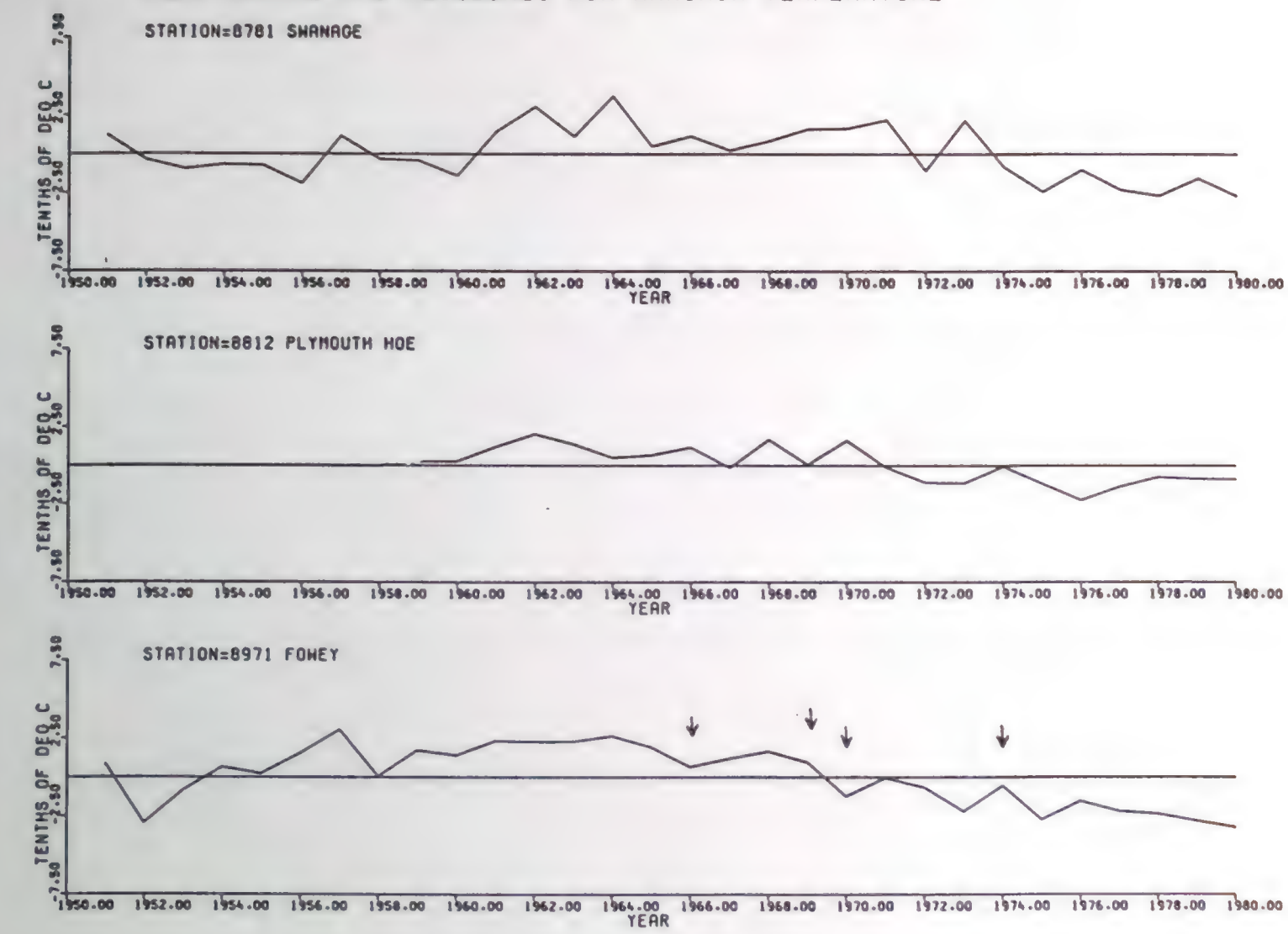




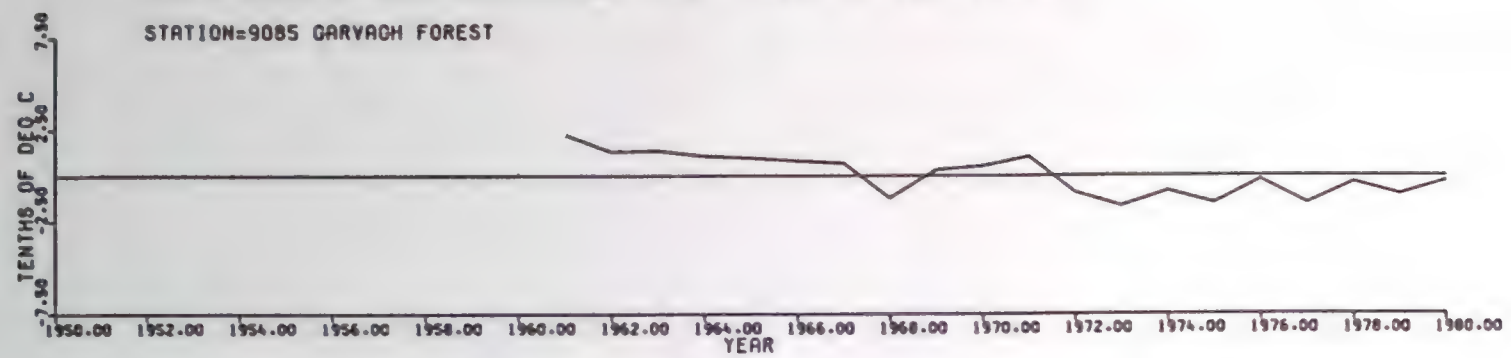


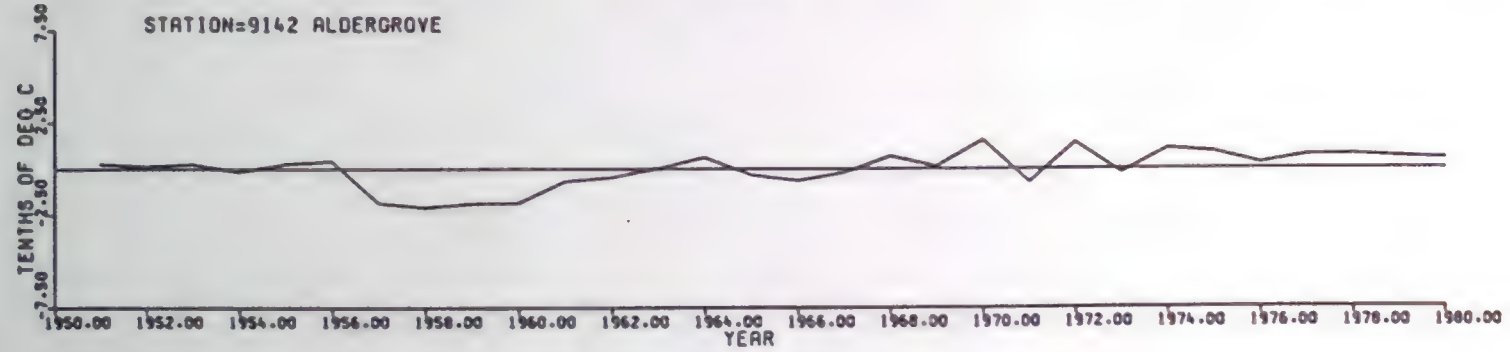


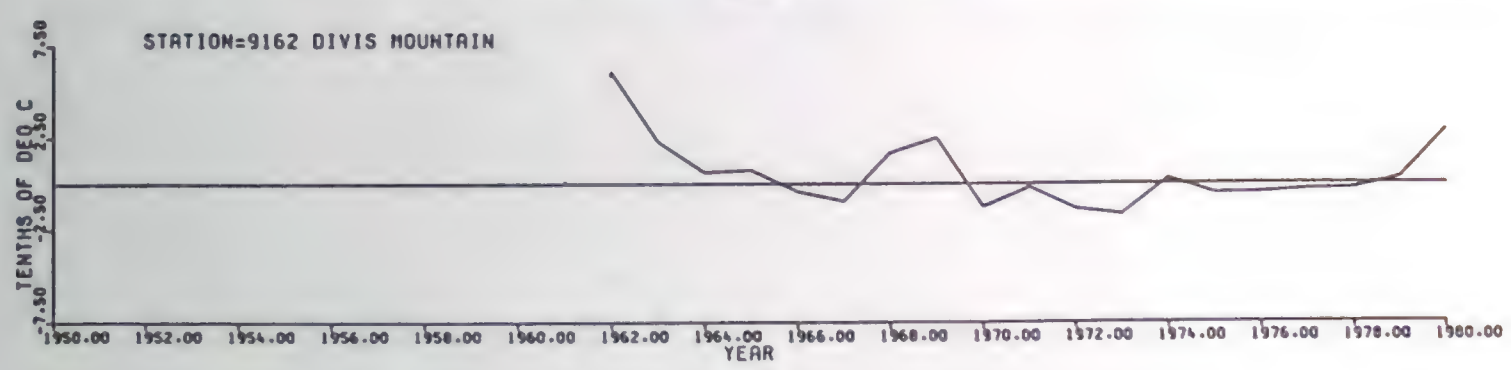
MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

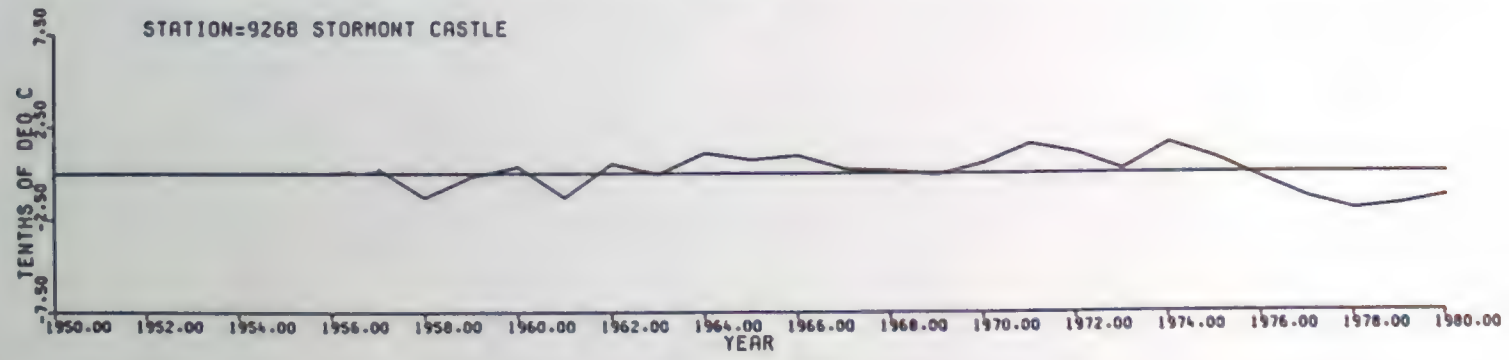


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

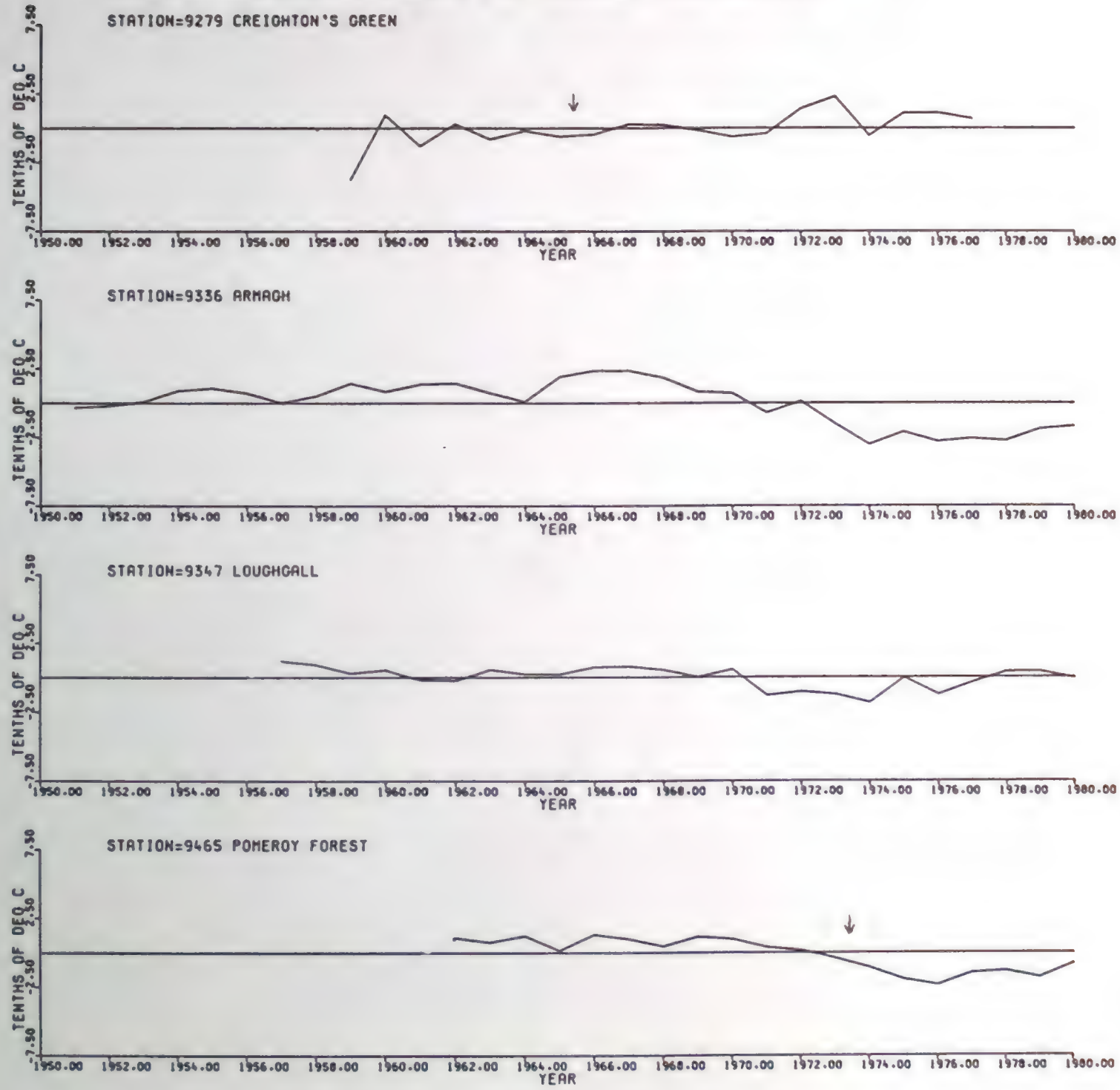






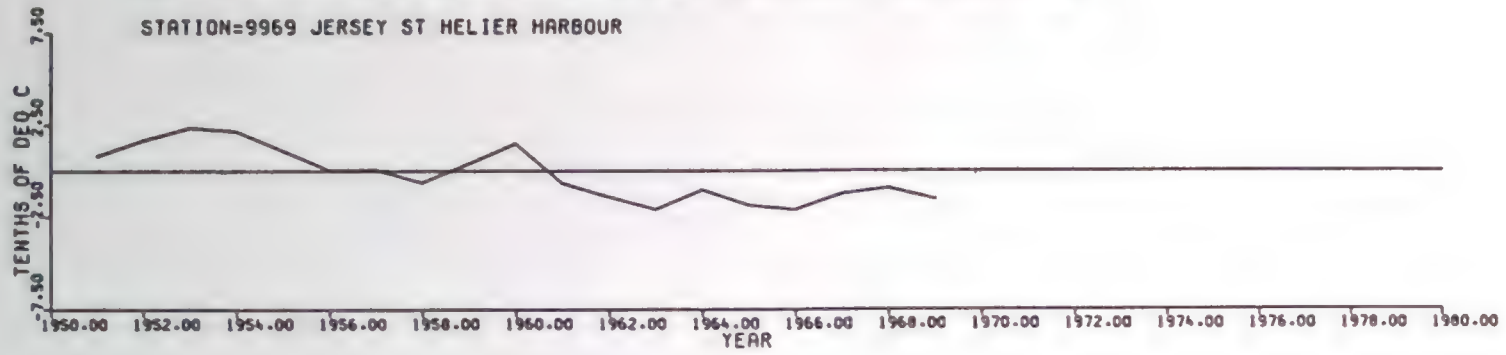


MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

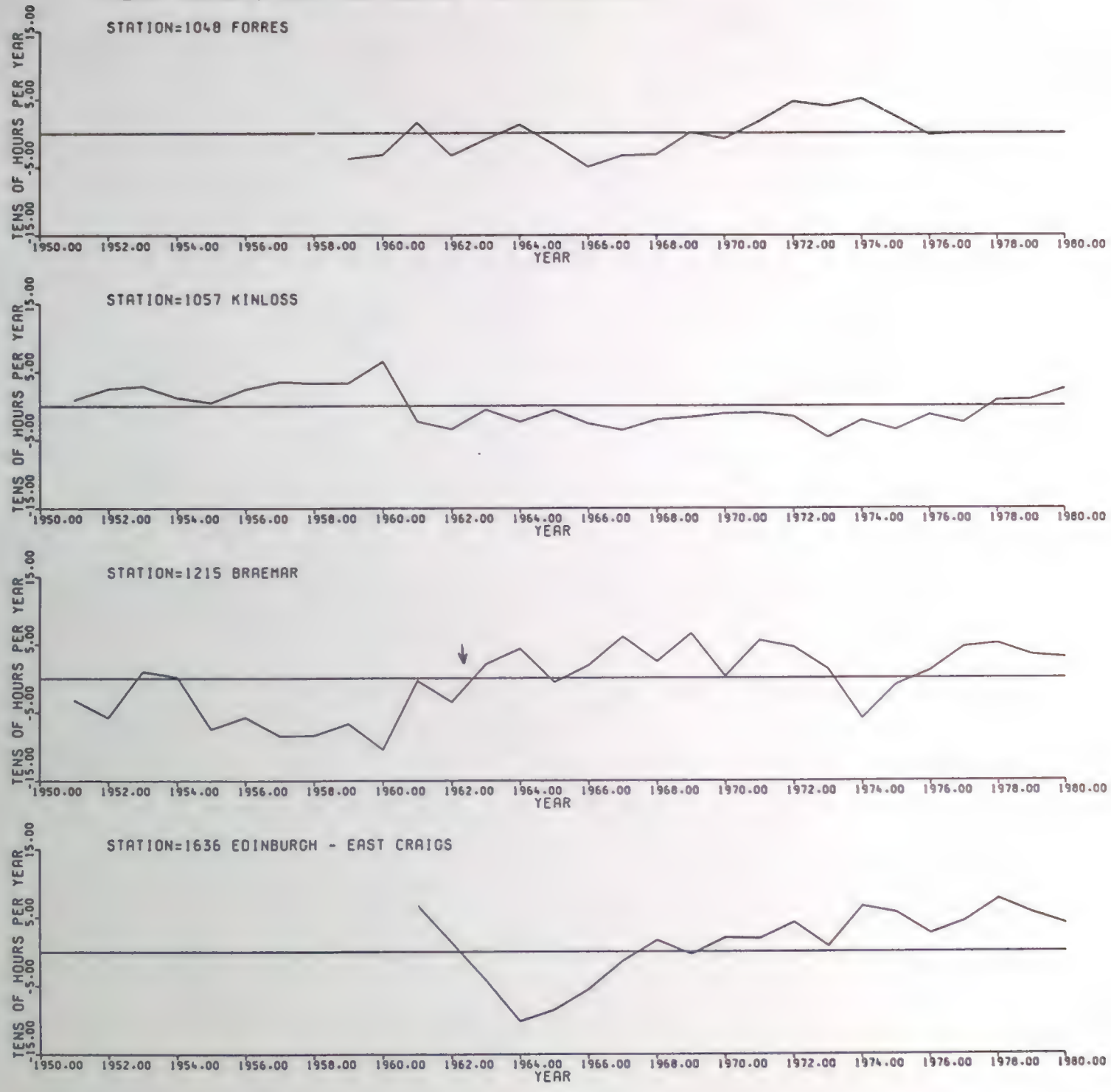


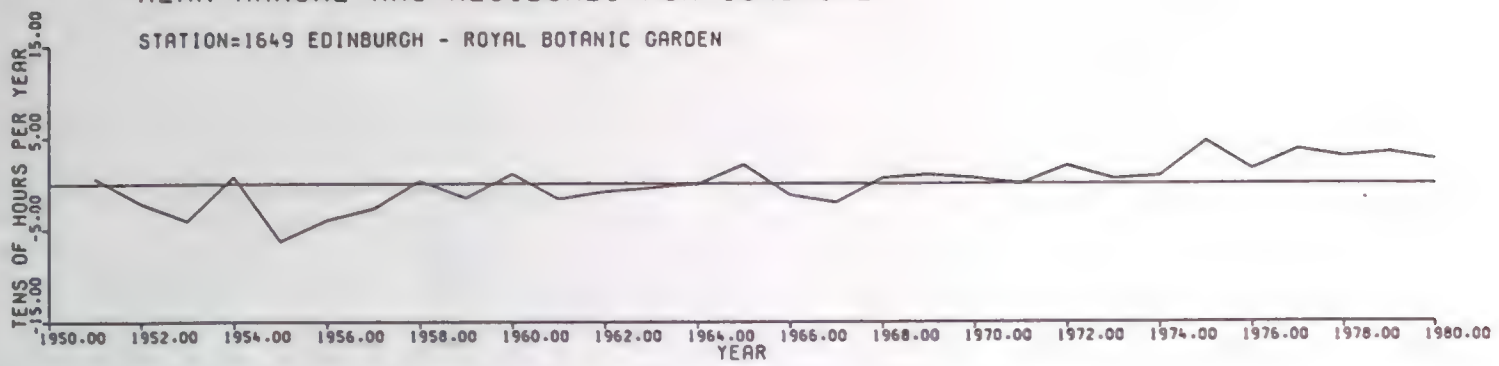
MEAN ANNUAL RMS RESIDUALS FOR MAXIMUM TEMPERATURE

STATION=9969 JERSEY ST HELIER HARBOUR

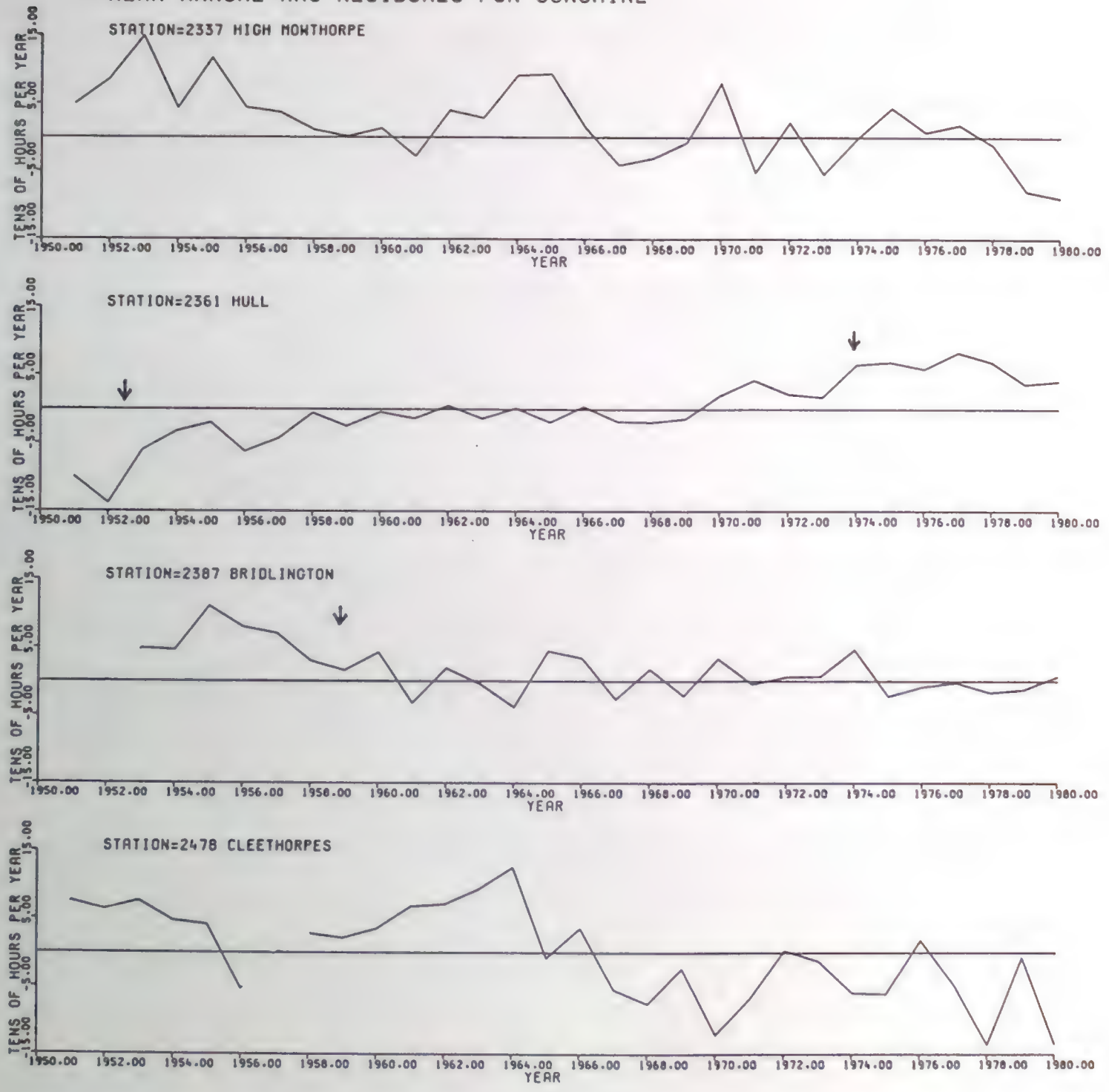


MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

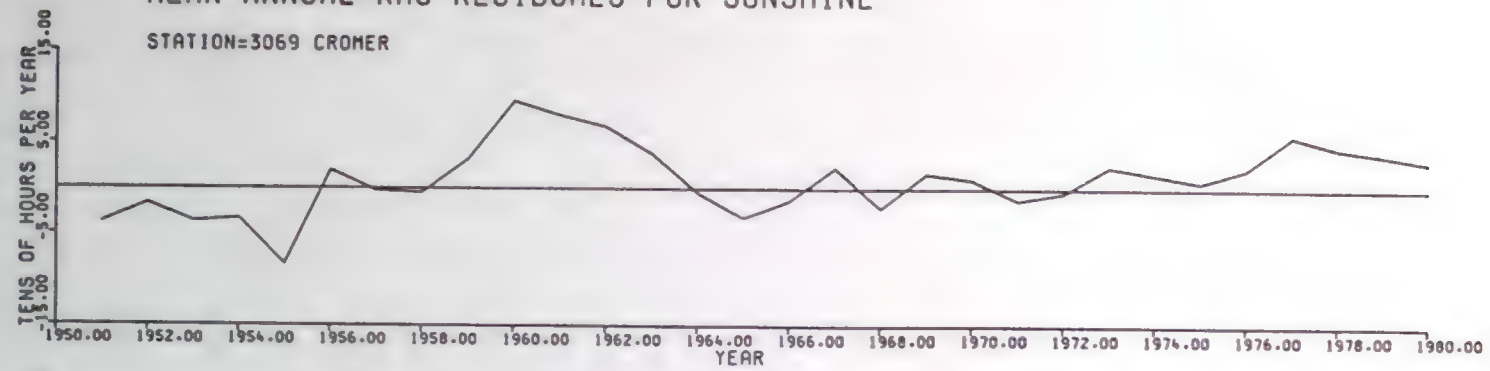


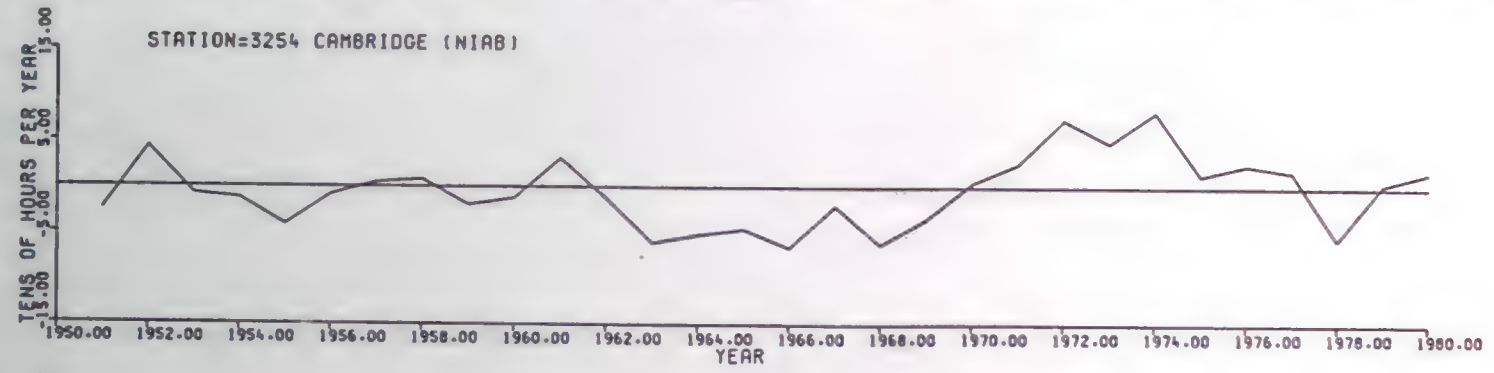

MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE
STATION=1649 EDINBURGH - ROYAL BOTANIC GARDEN
TENS OF HOURS PER YEAR
15.00
5.00
-5.00
-15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

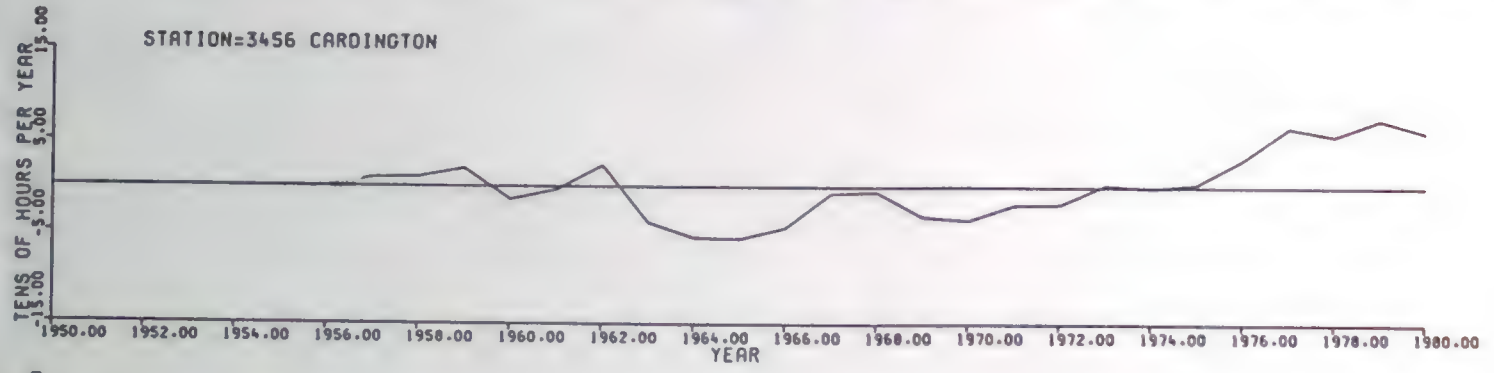
MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

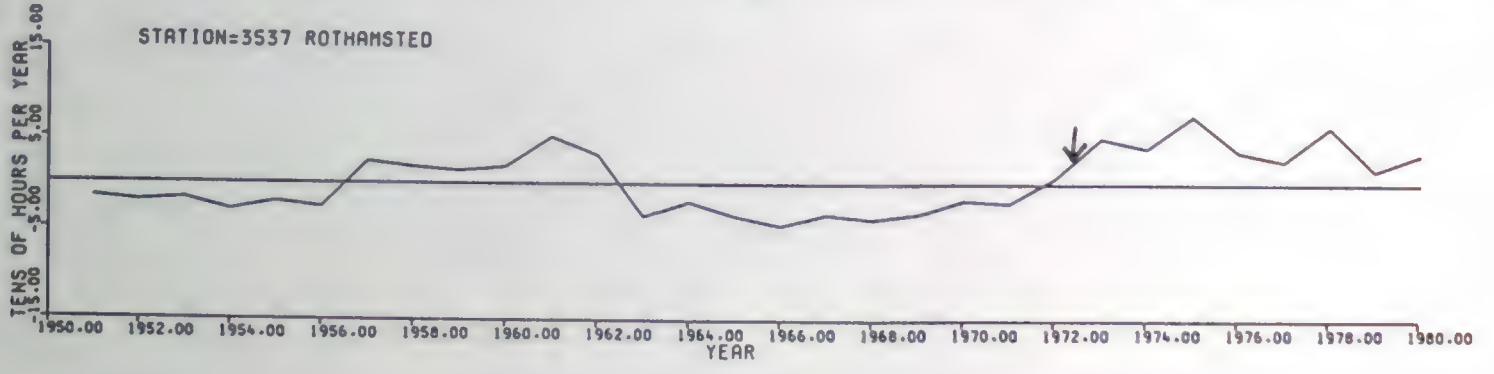


MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

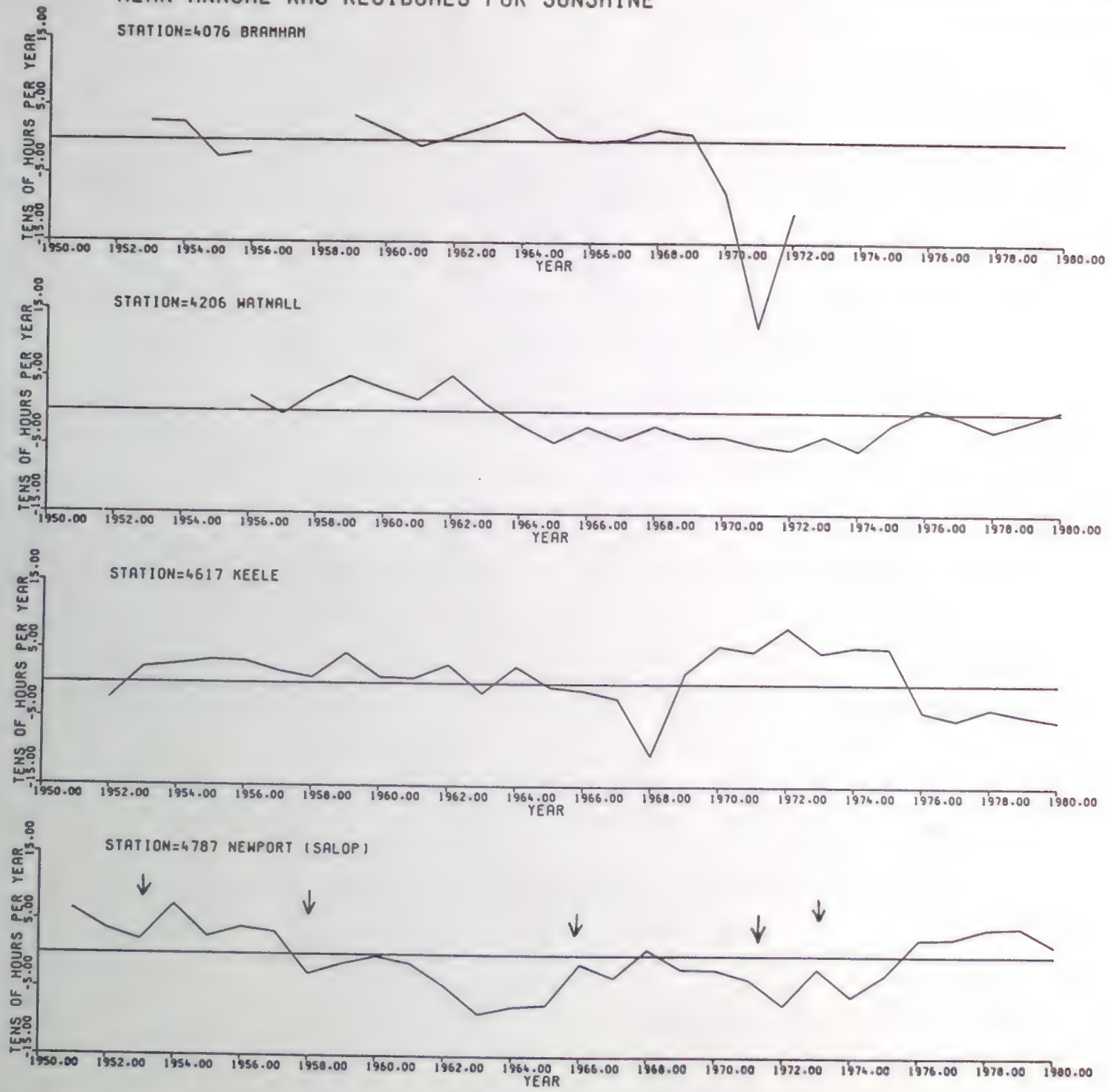


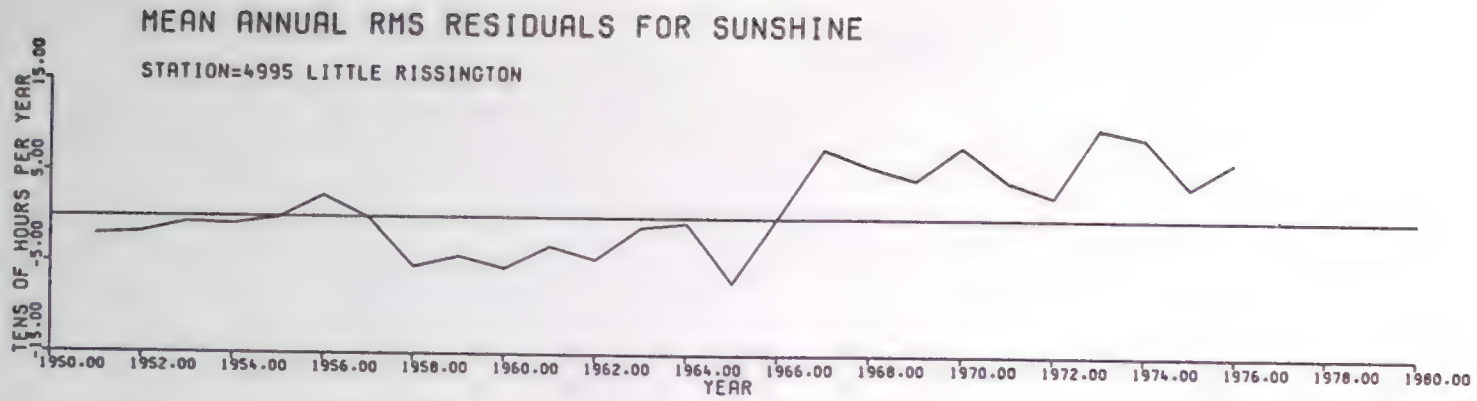




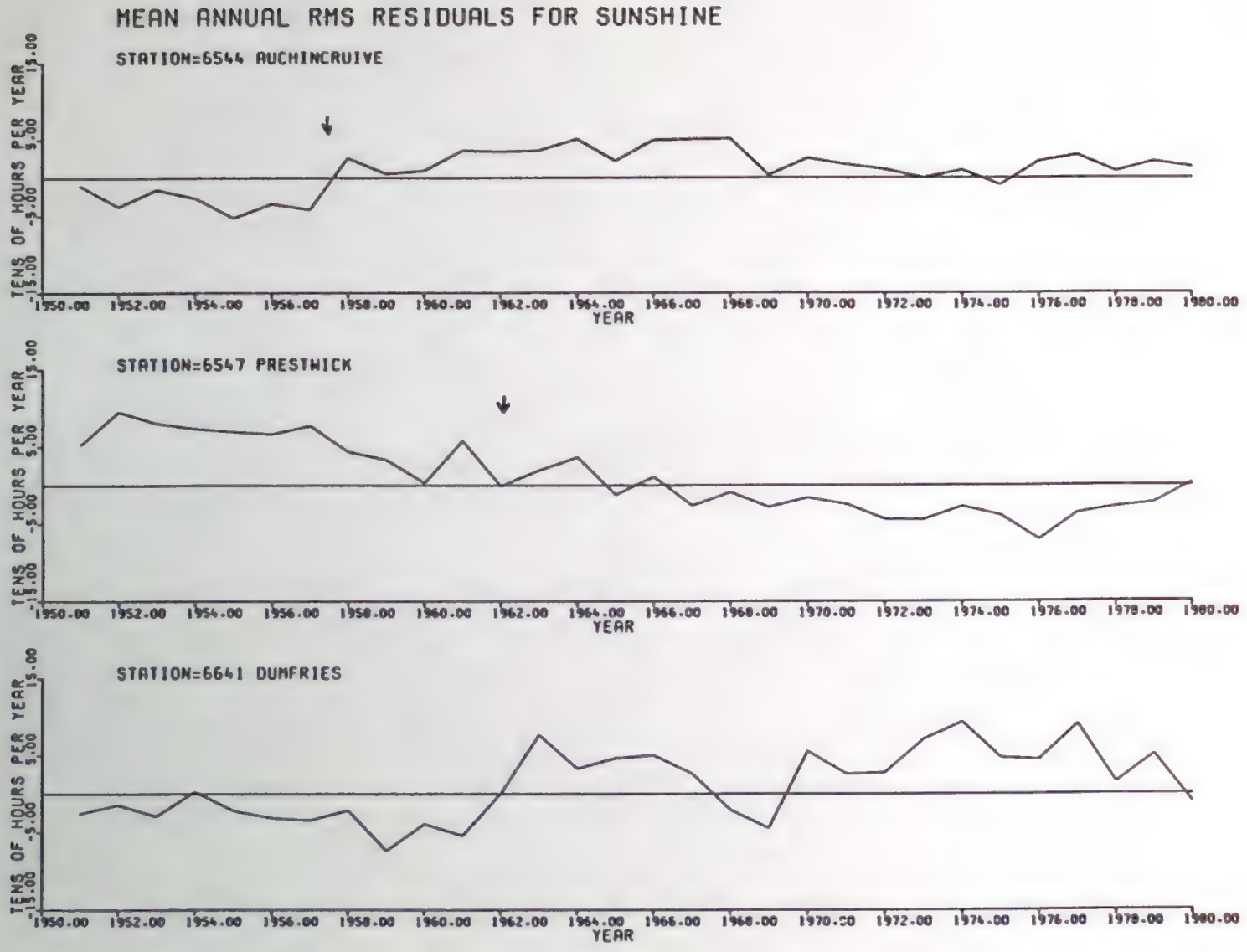


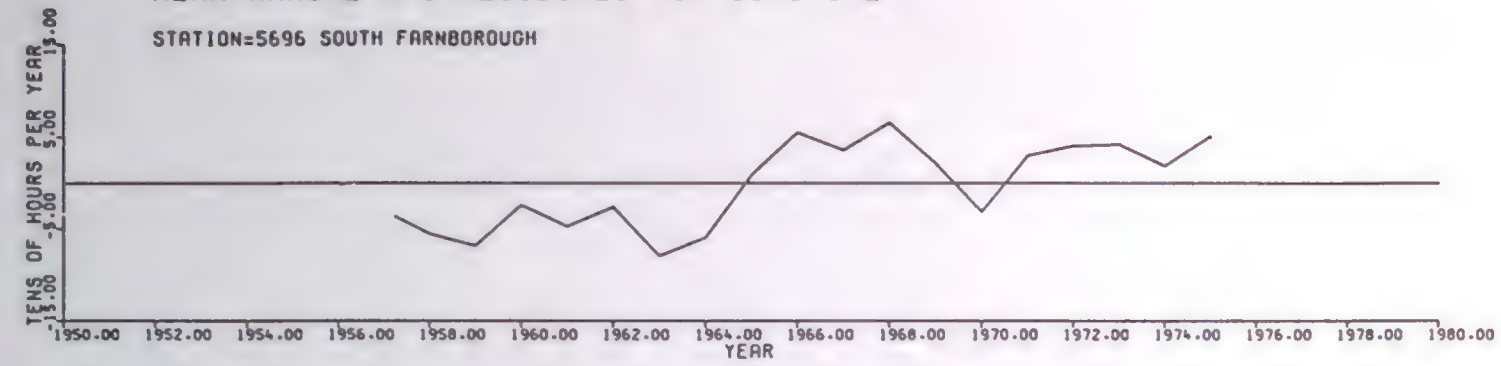
MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE



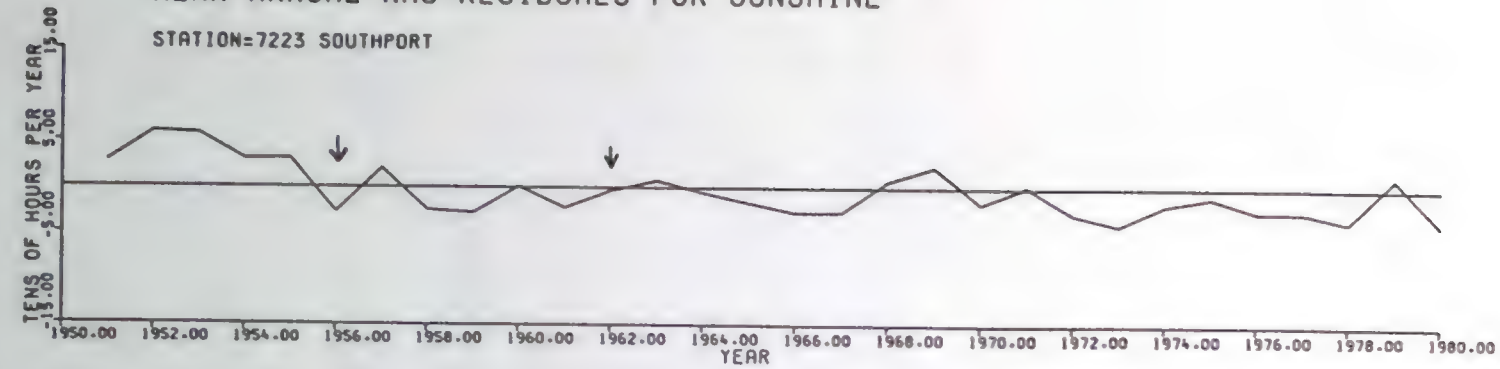

MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE
STATION=4995 LITTLE RISSINGTON
TENS OF HOURS PER YEAR
15.00
5.00
-5.00
-15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

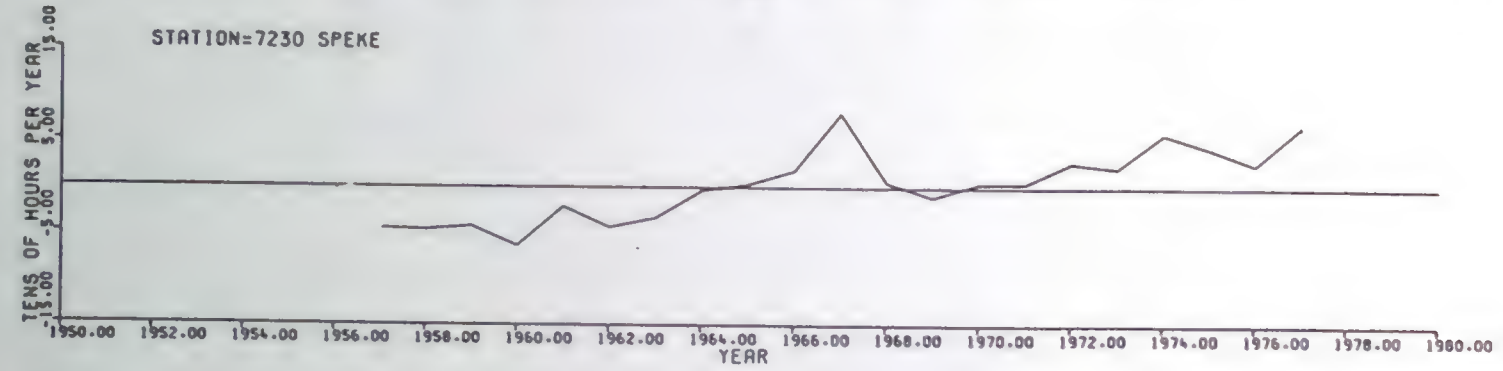
MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

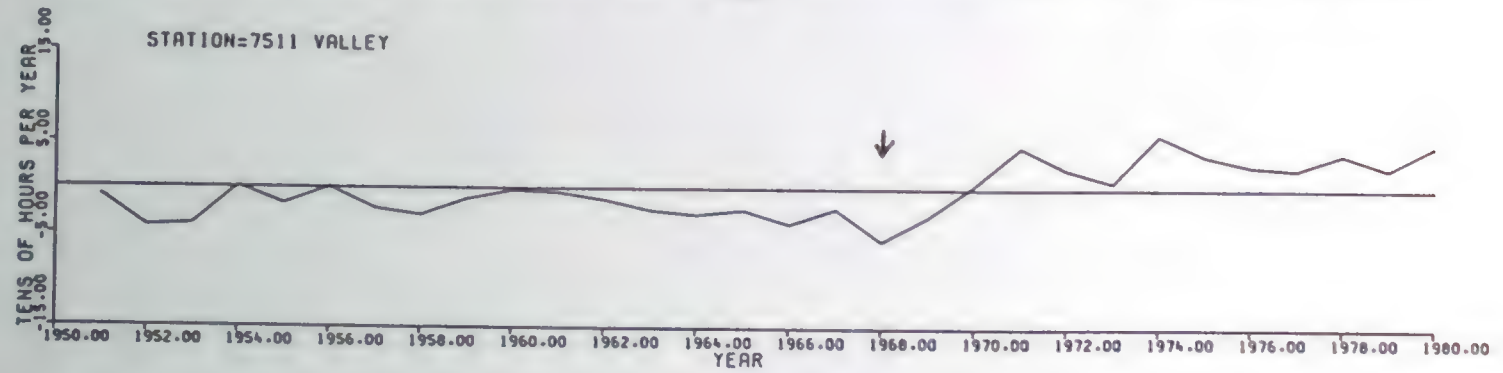


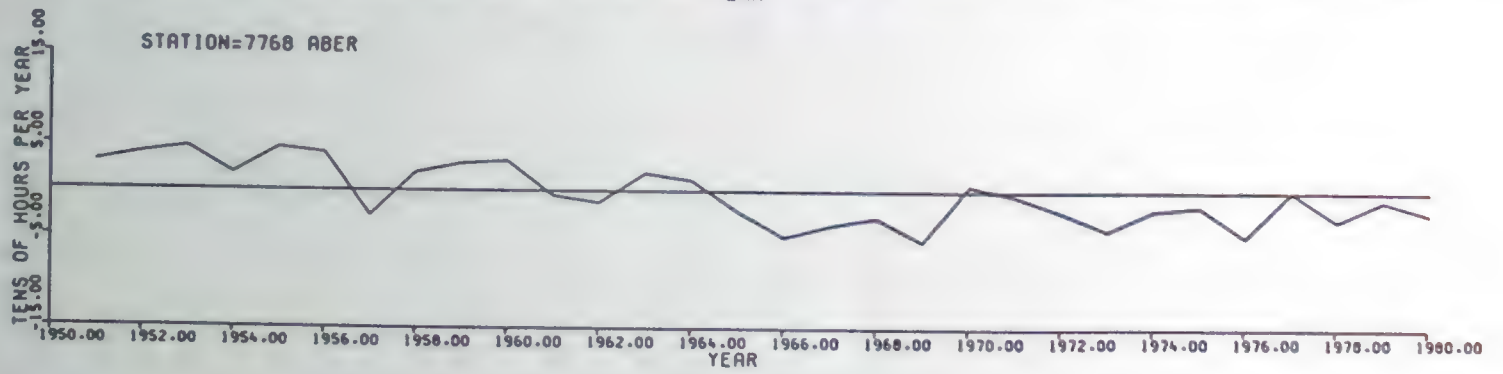

MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE
STATION=5696 SOUTH FARNBOROUGH
TENS OF HOURS PER YEAR
15.00
5.00
-5.00
-15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

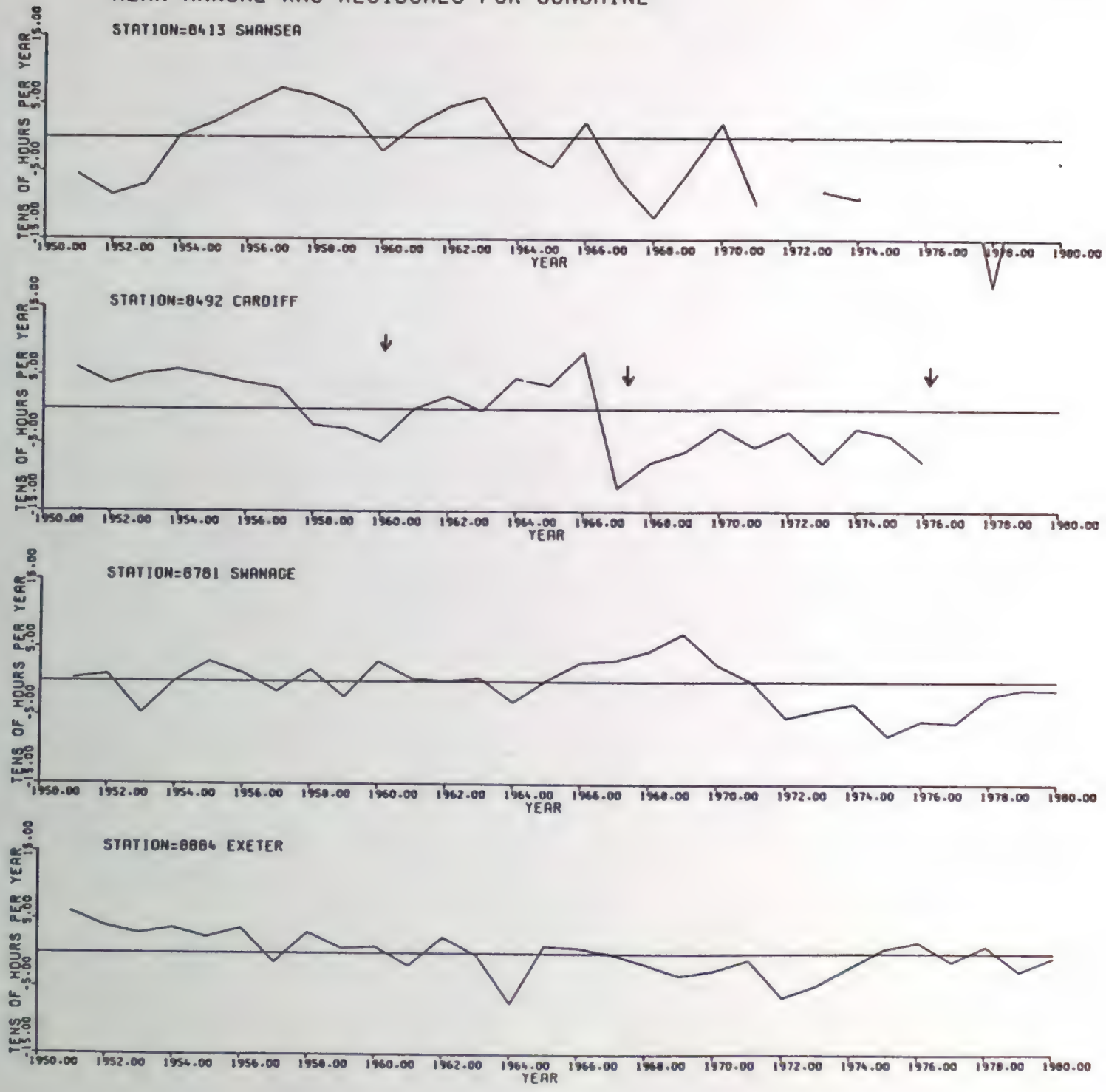


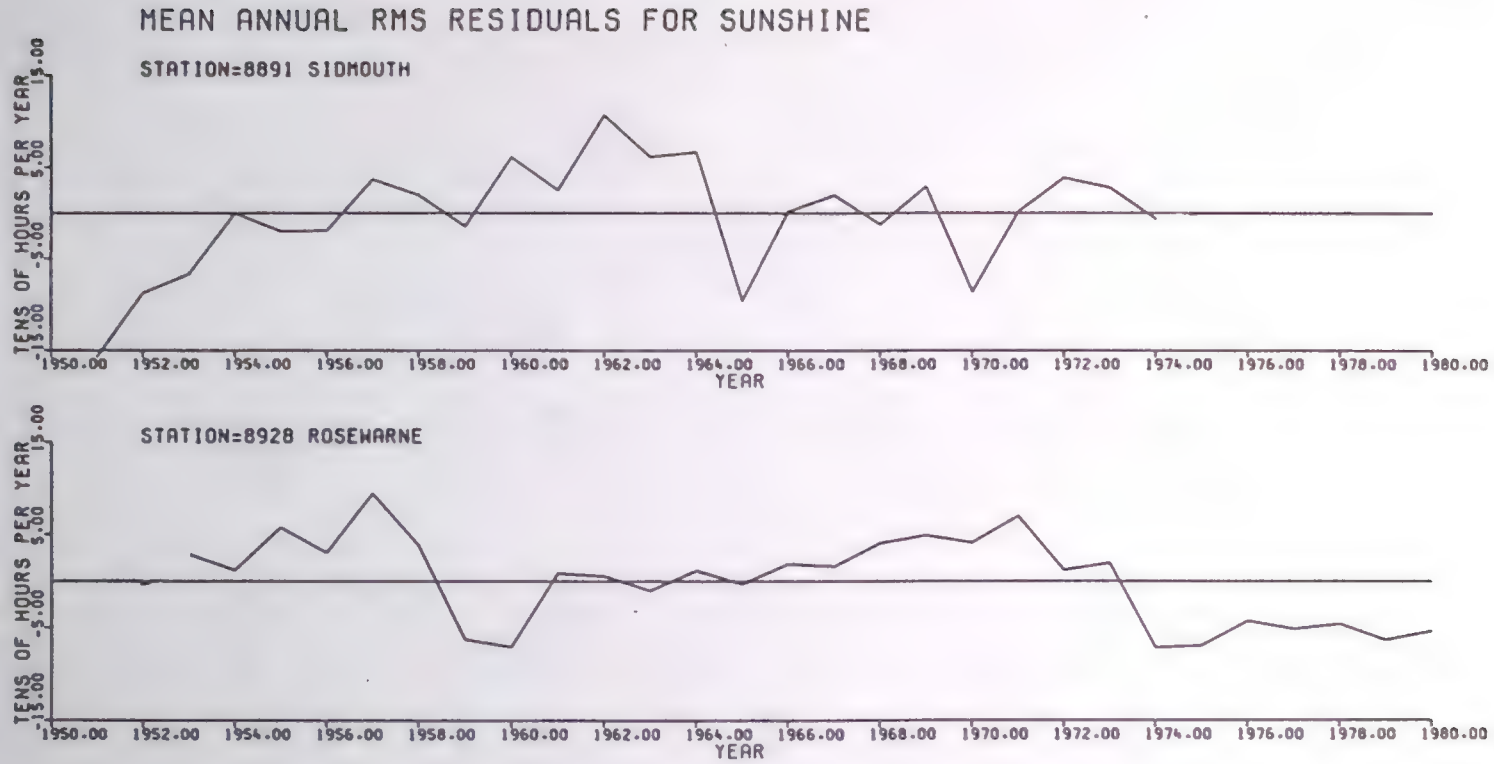




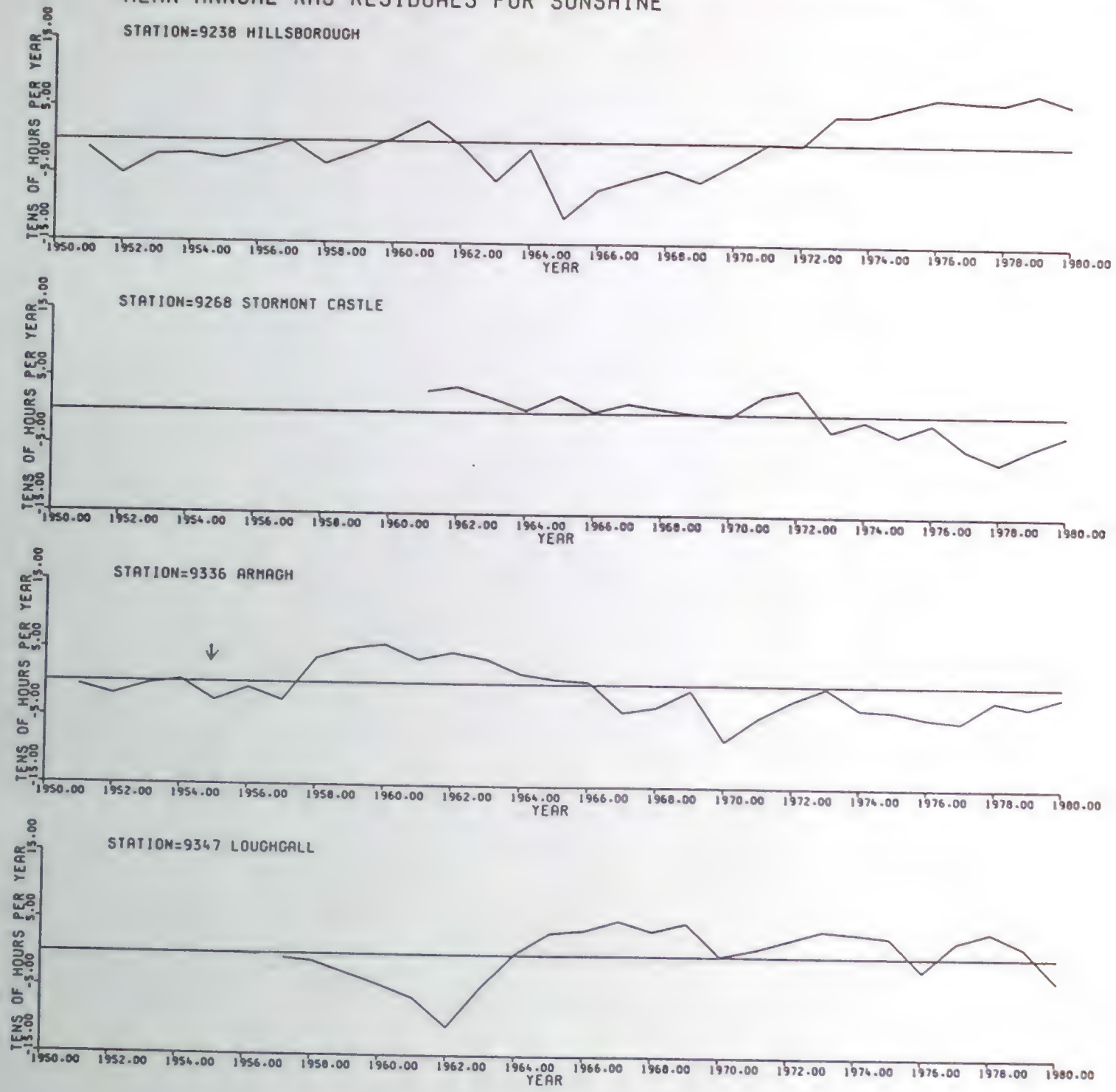


MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

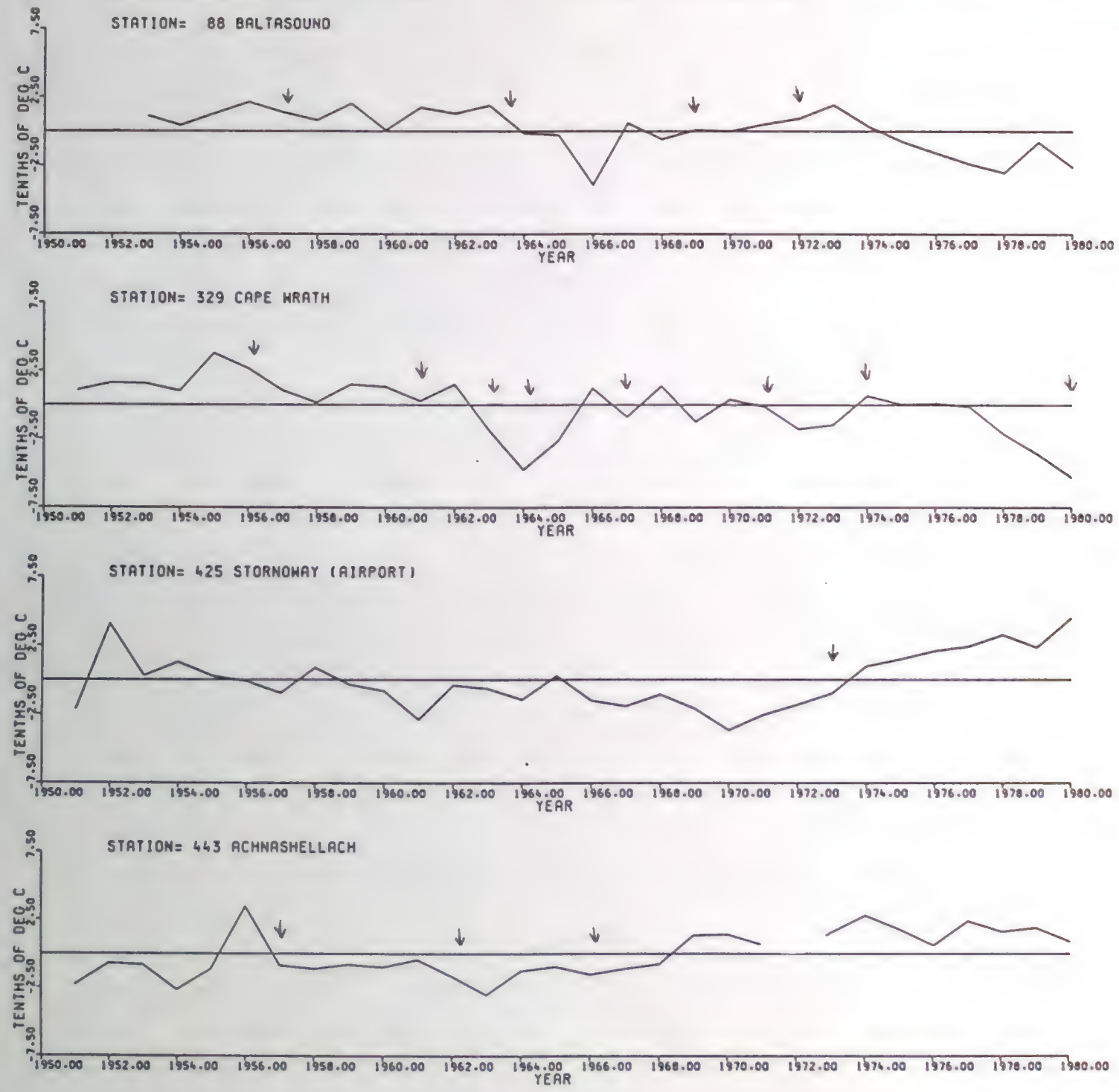



MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE
STATION=8891 SIDMOUTH
TENS OF HOURS PER YEAR
15.00
5.00
-5.00
-15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR
STATION=8928 ROSEWARNE
TENS OF HOURS PER YEAR
15.00
5.00
-5.00
-15.00
1950.00
1952.00
1954.00
1956.00
1958.00
1960.00
1962.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
YEAR

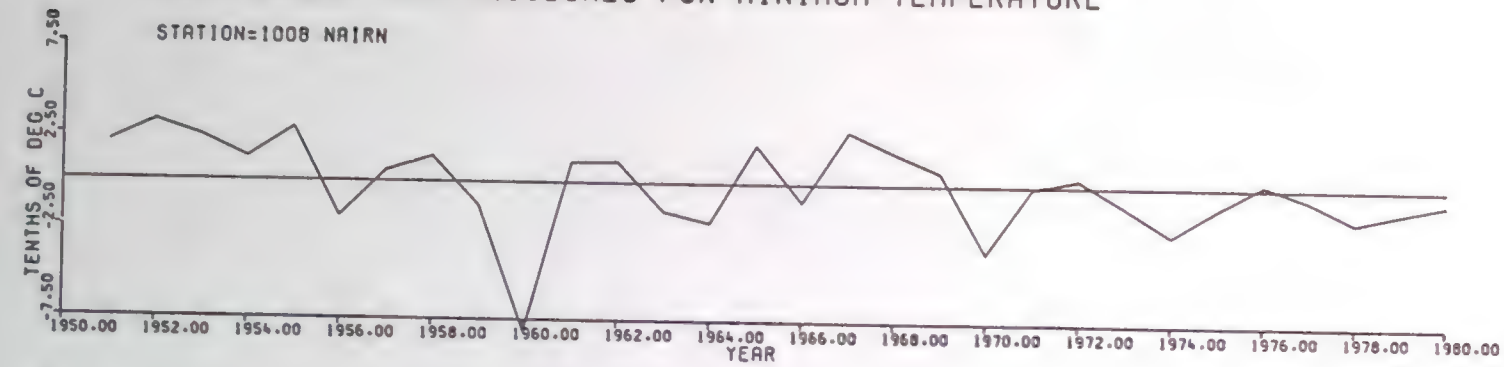
MEAN ANNUAL RMS RESIDUALS FOR SUNSHINE

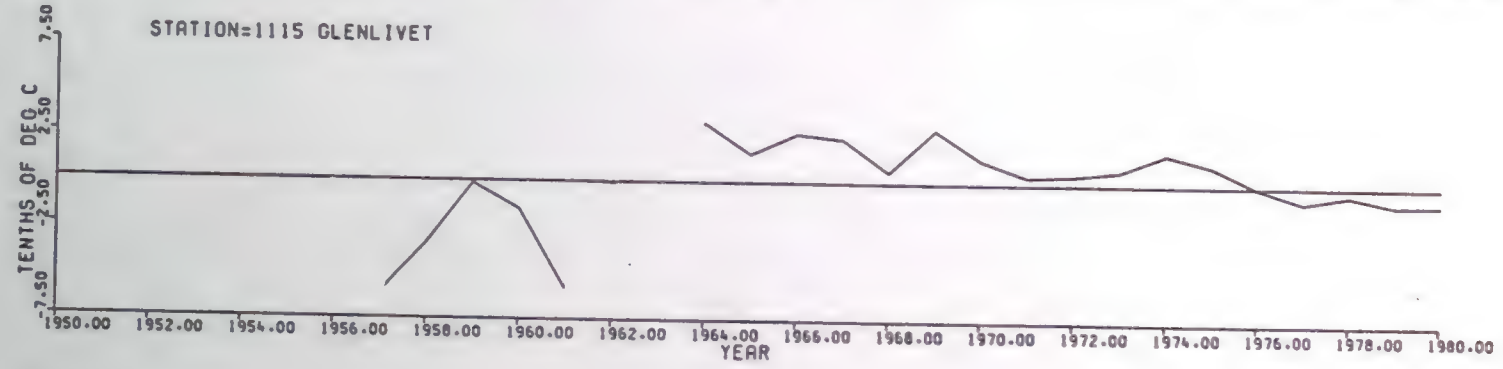


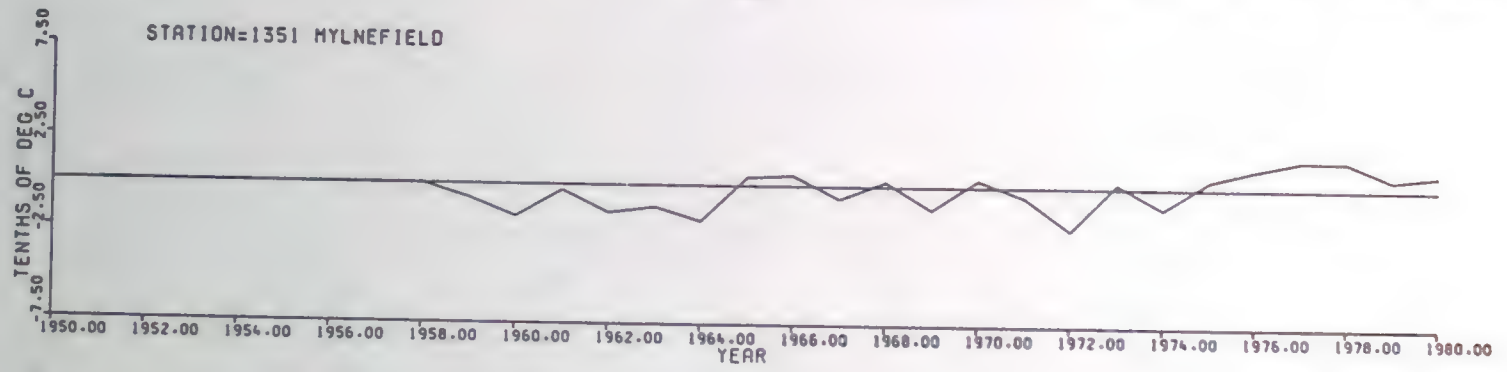
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE

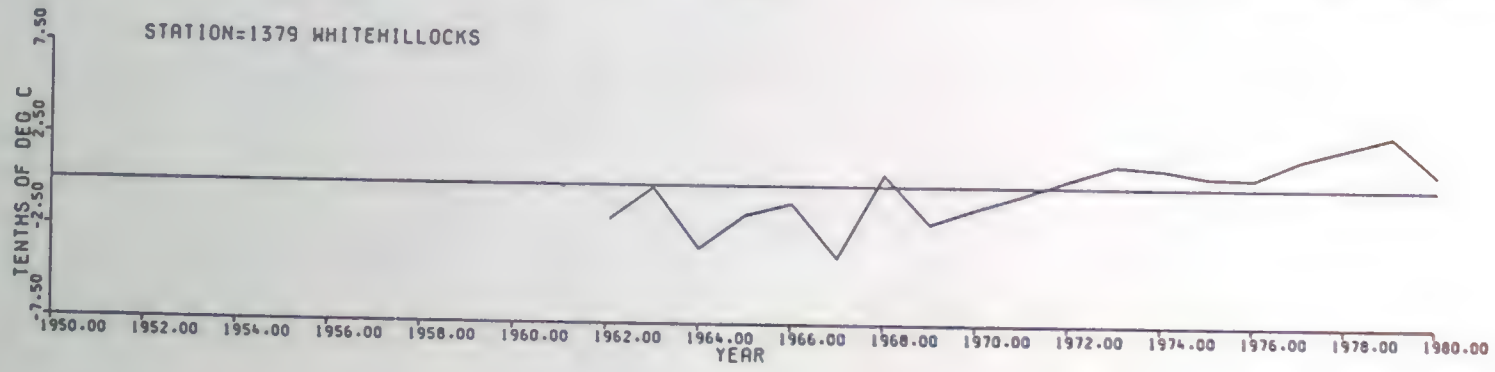


MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE

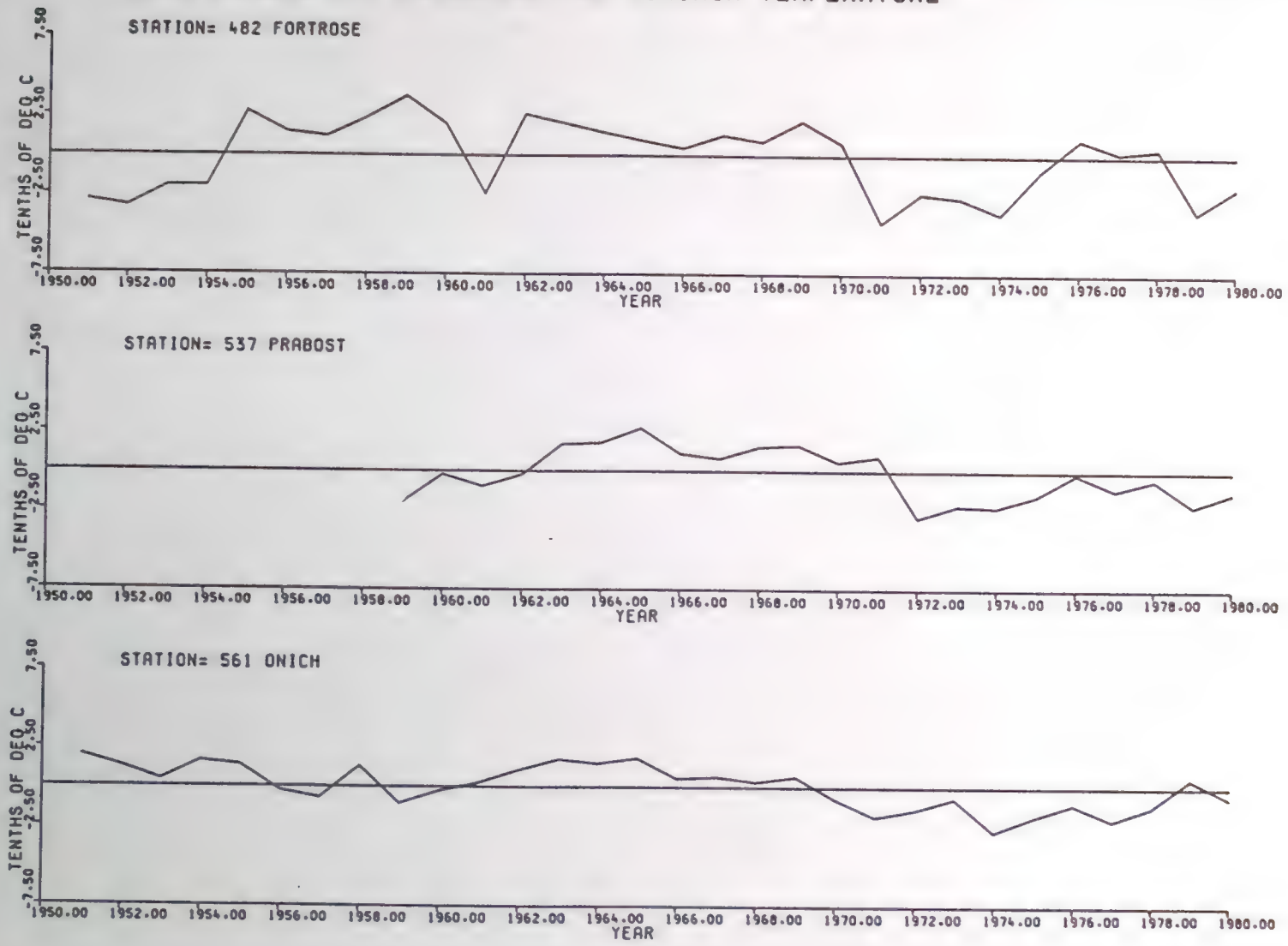




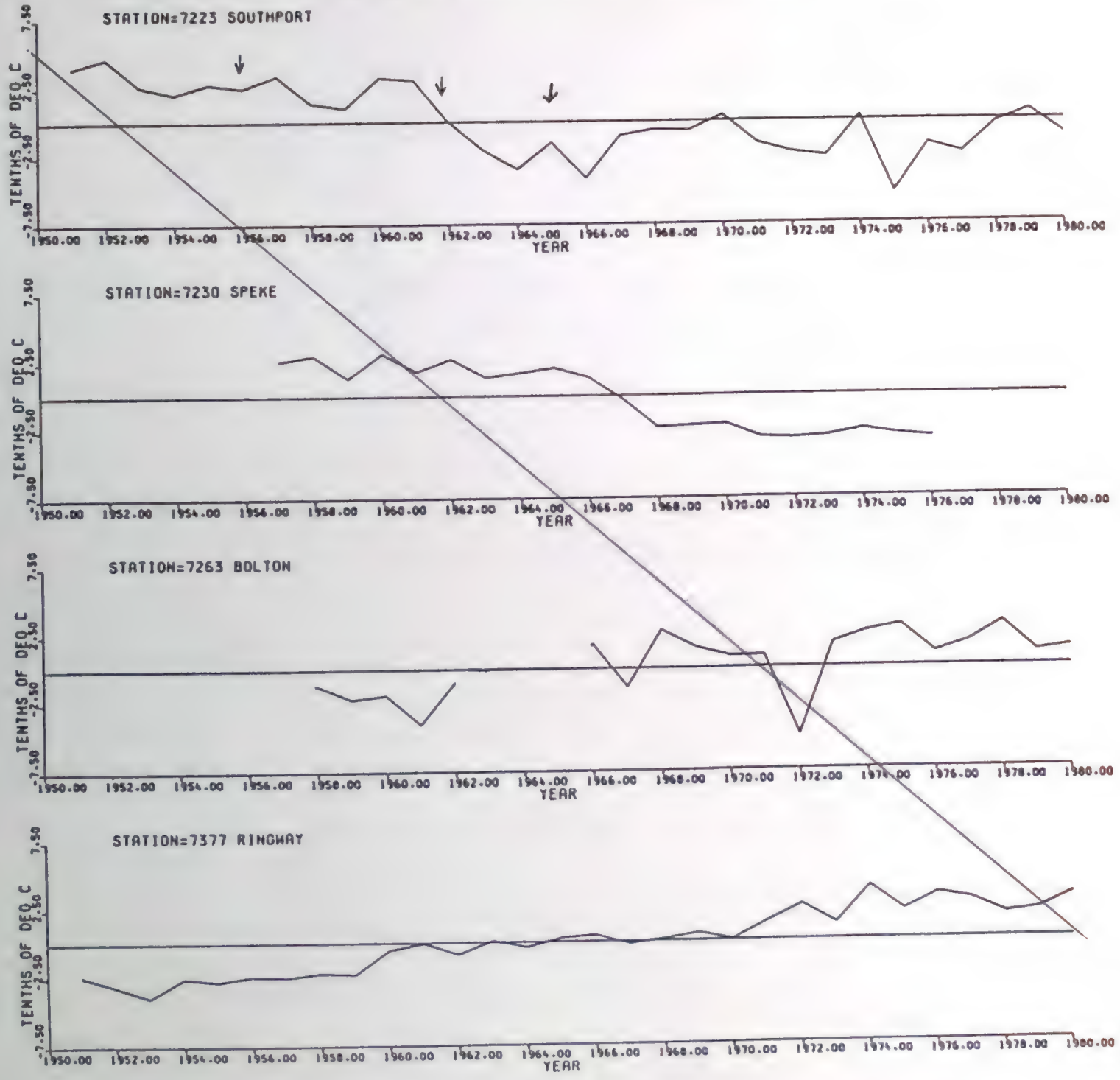




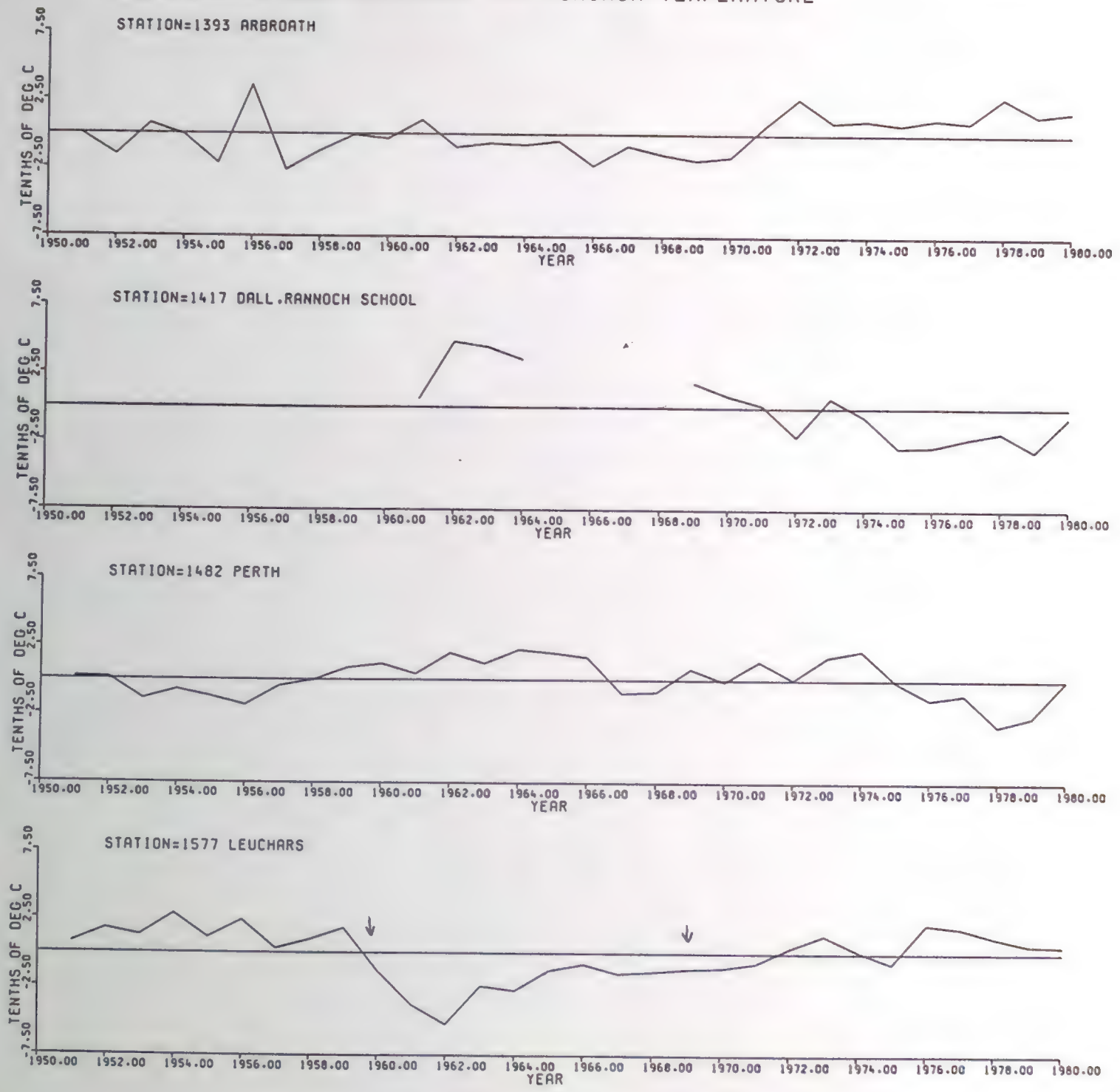
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



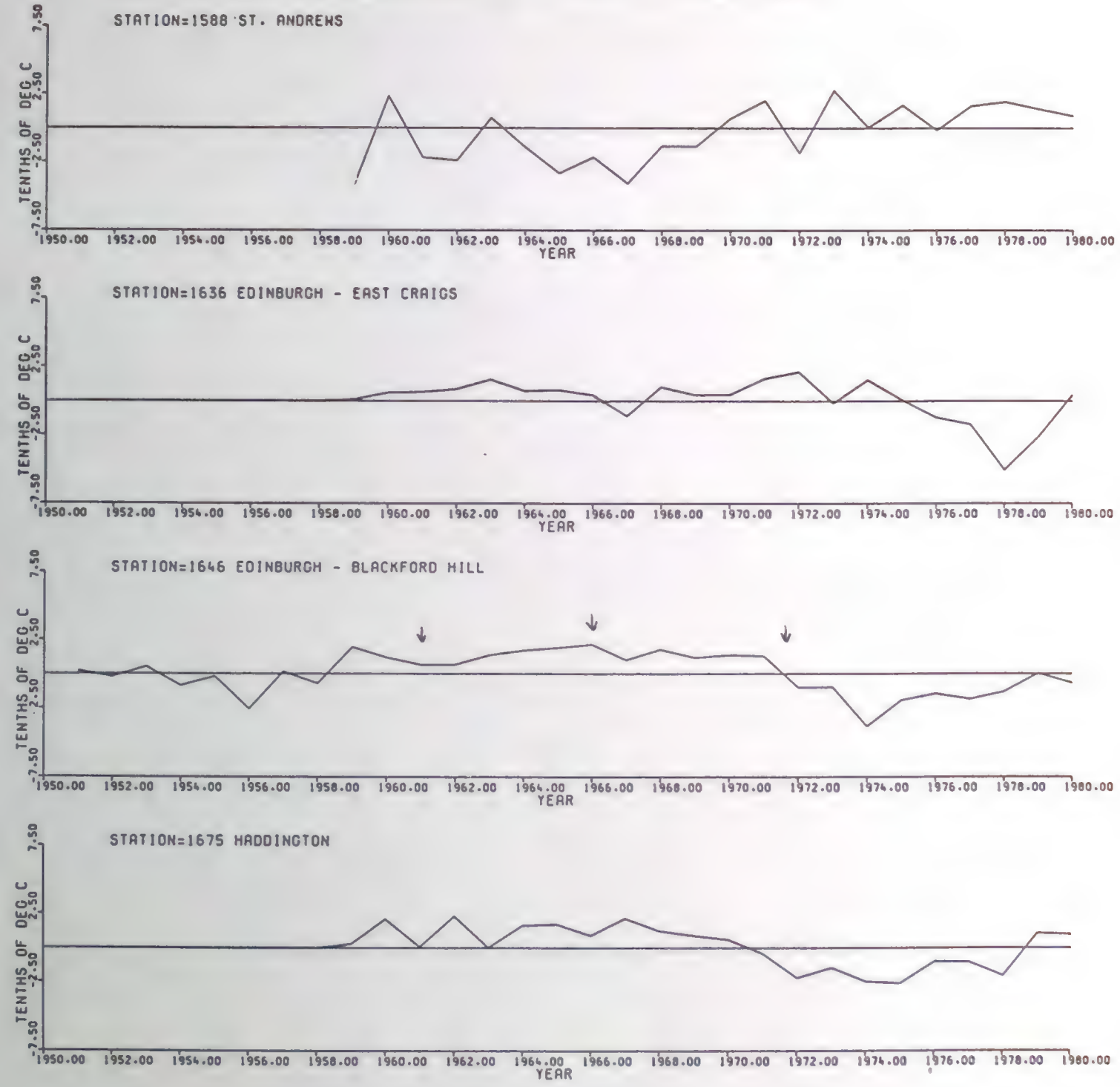
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



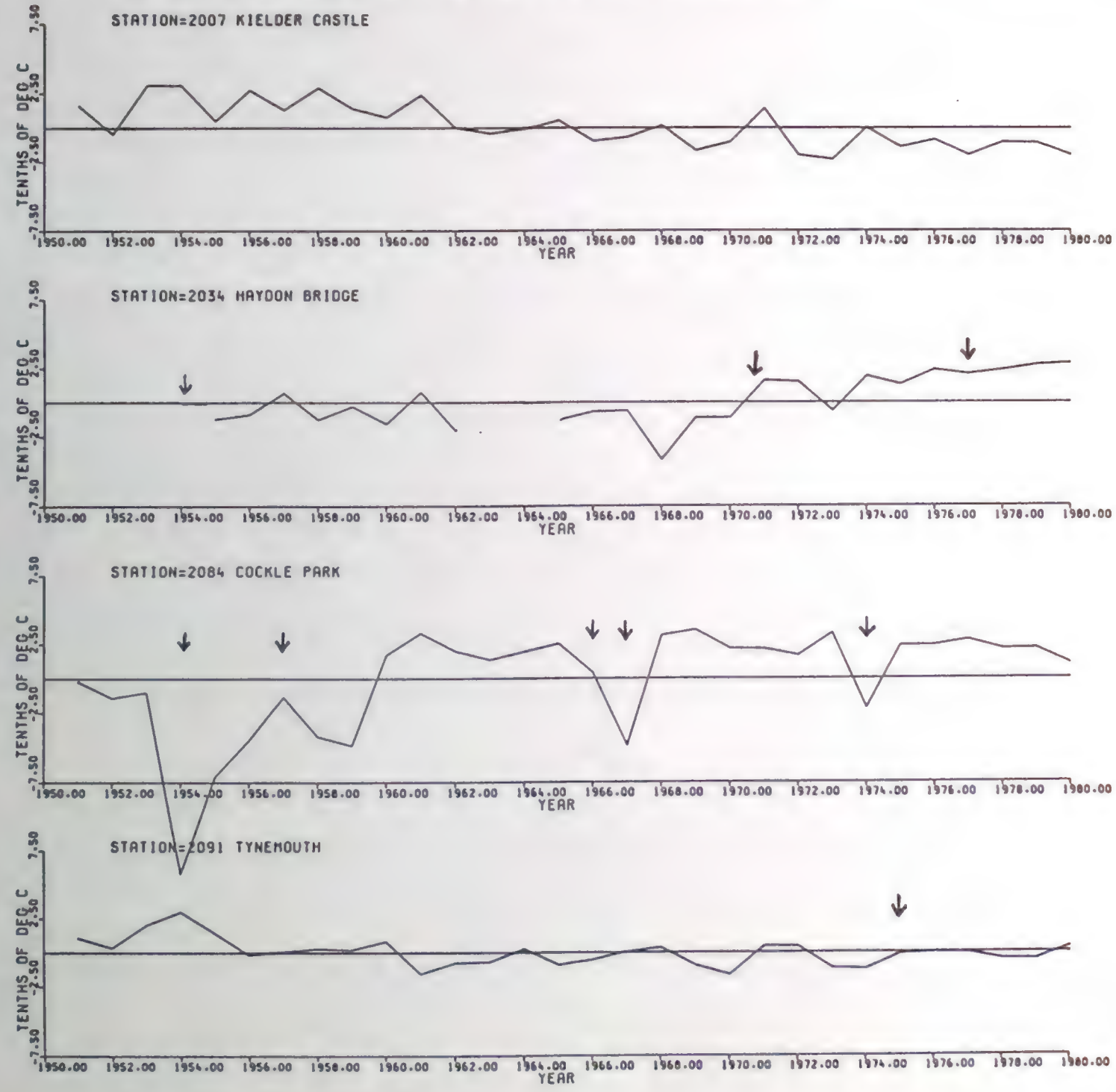
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



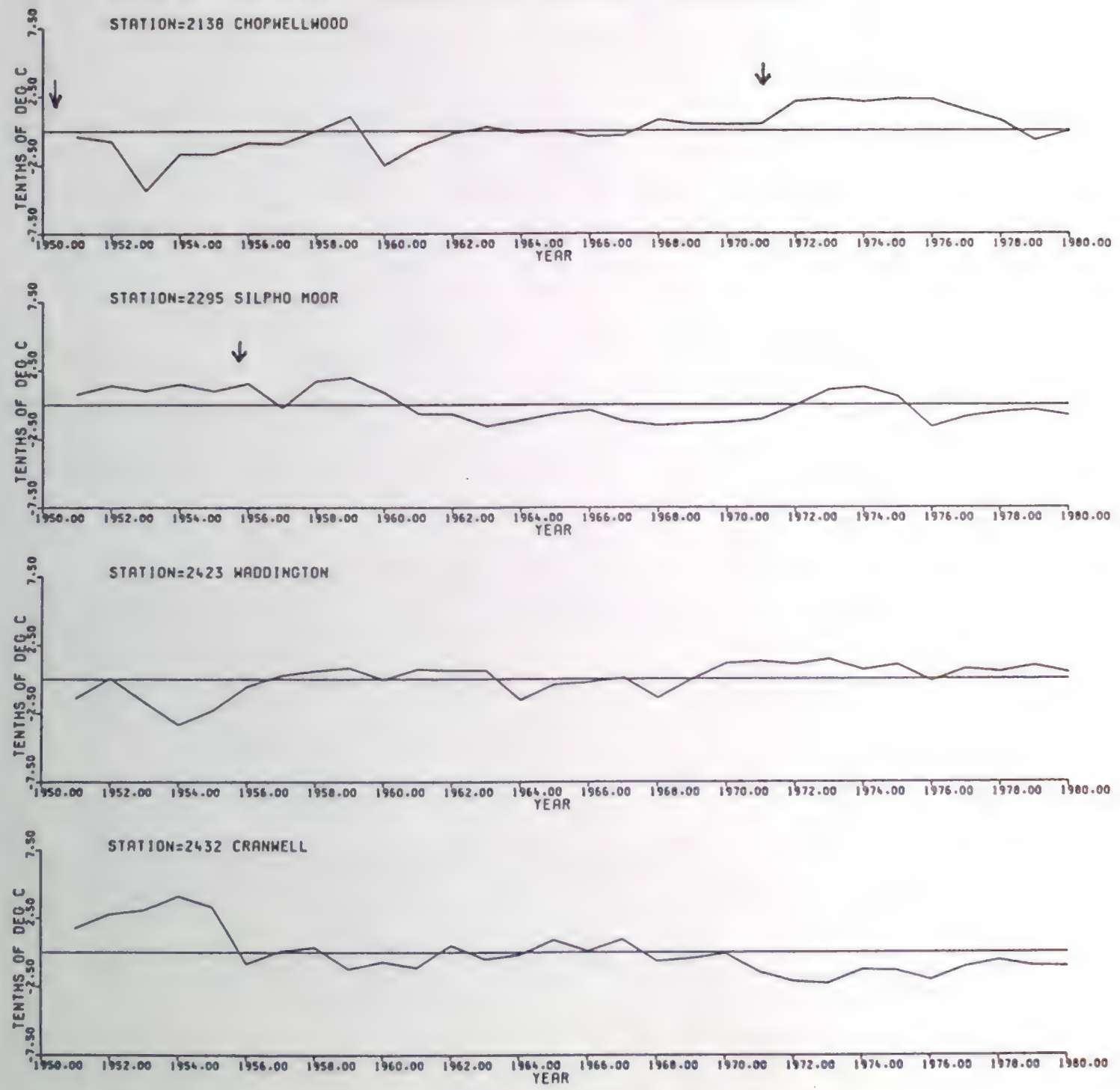
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



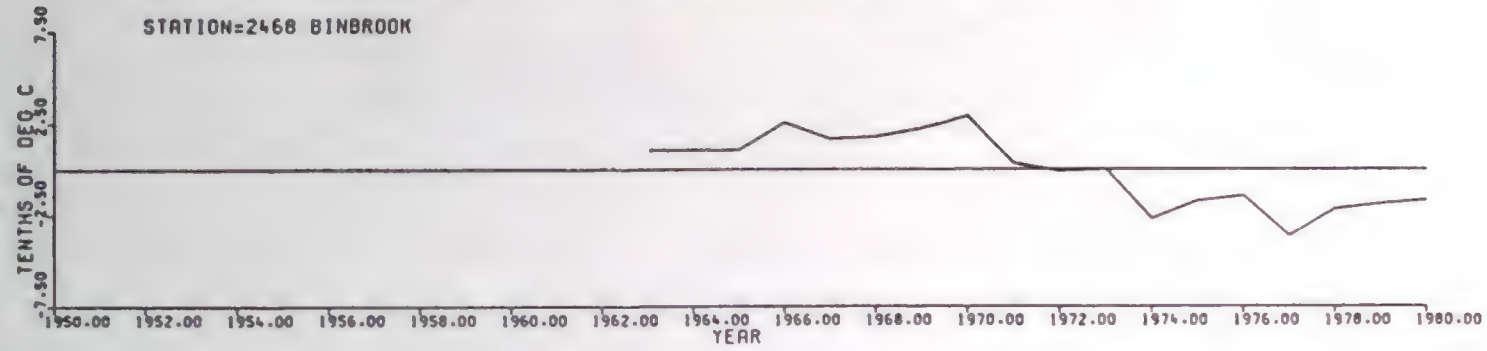
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



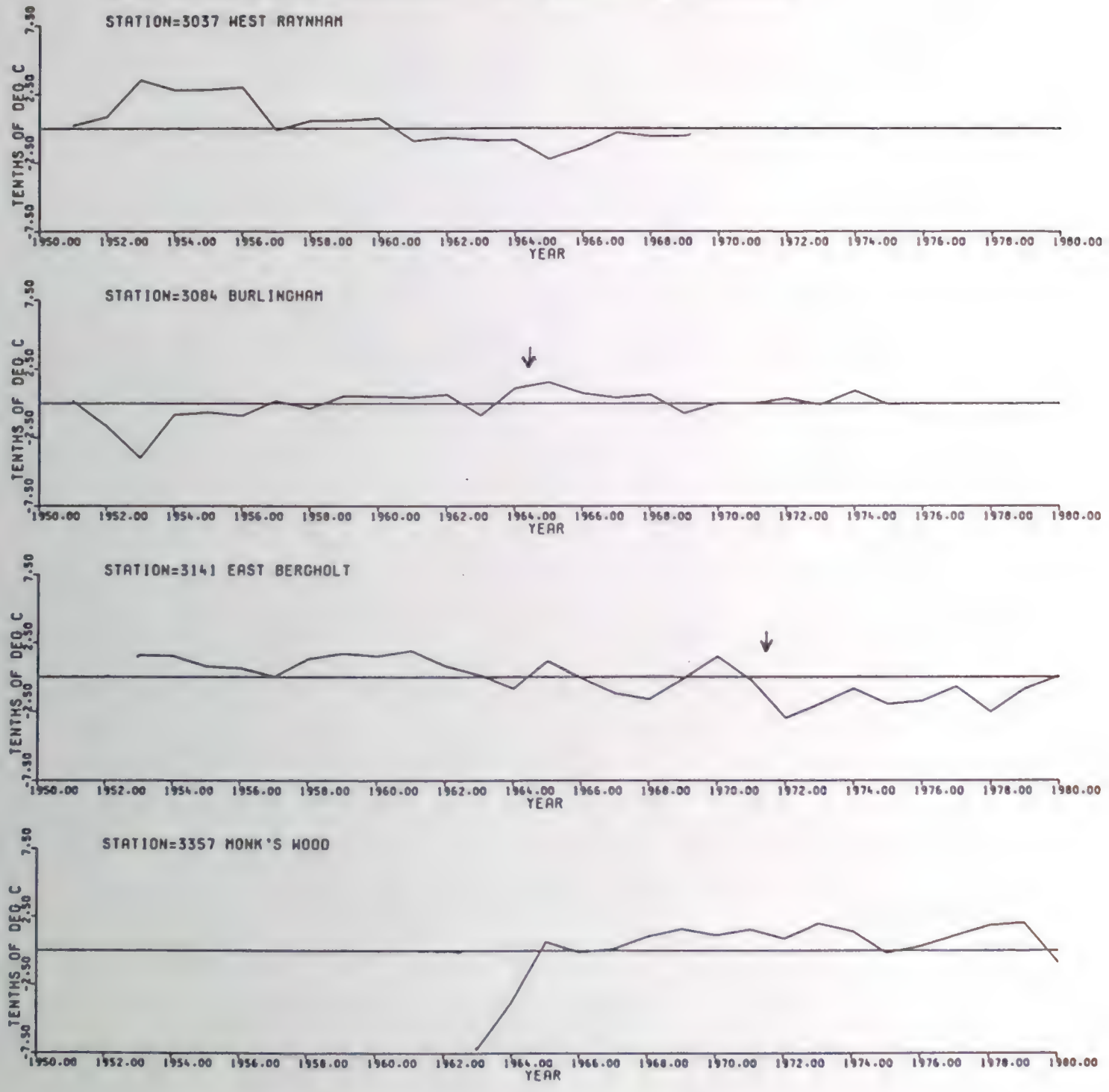
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



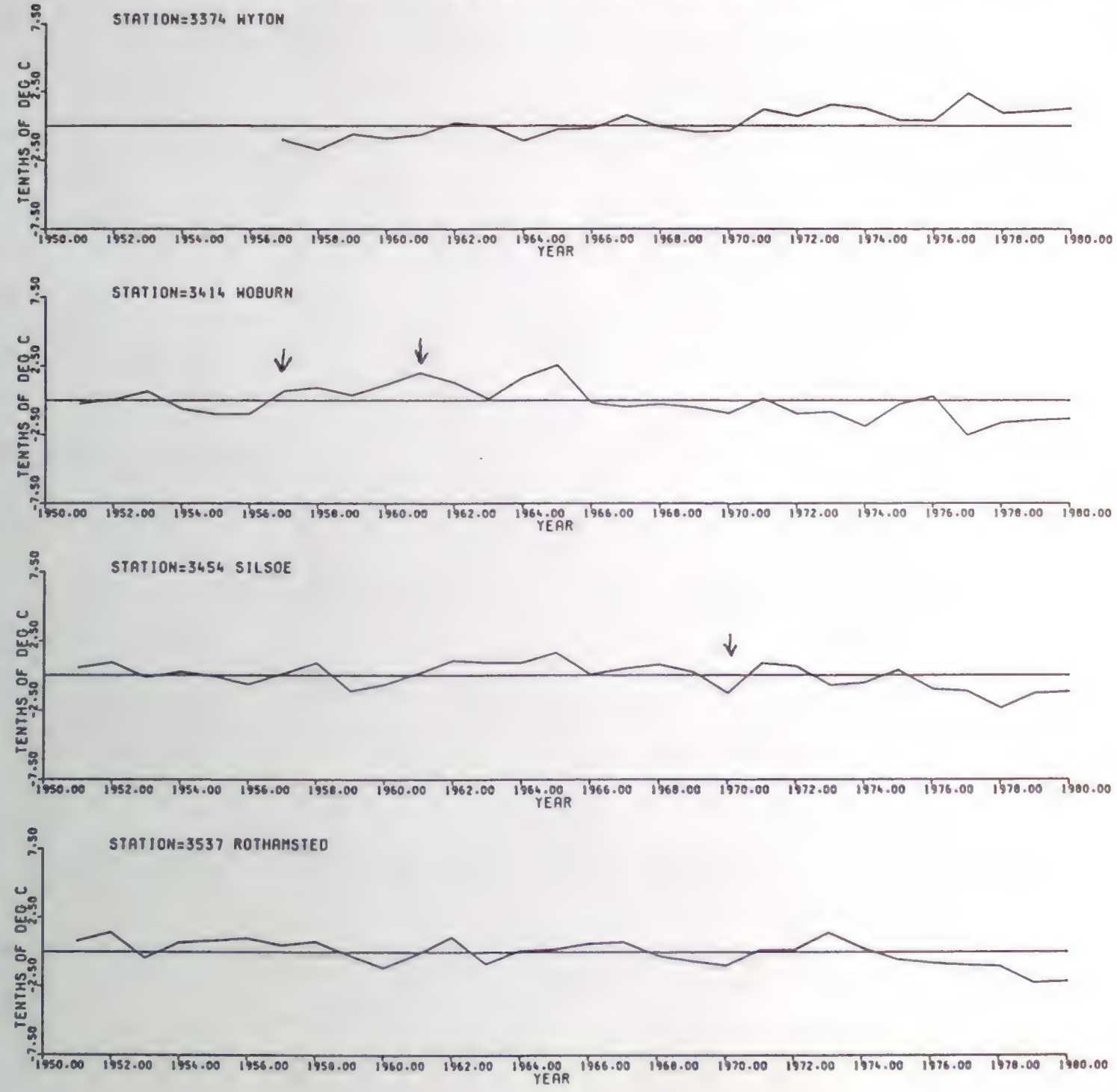
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



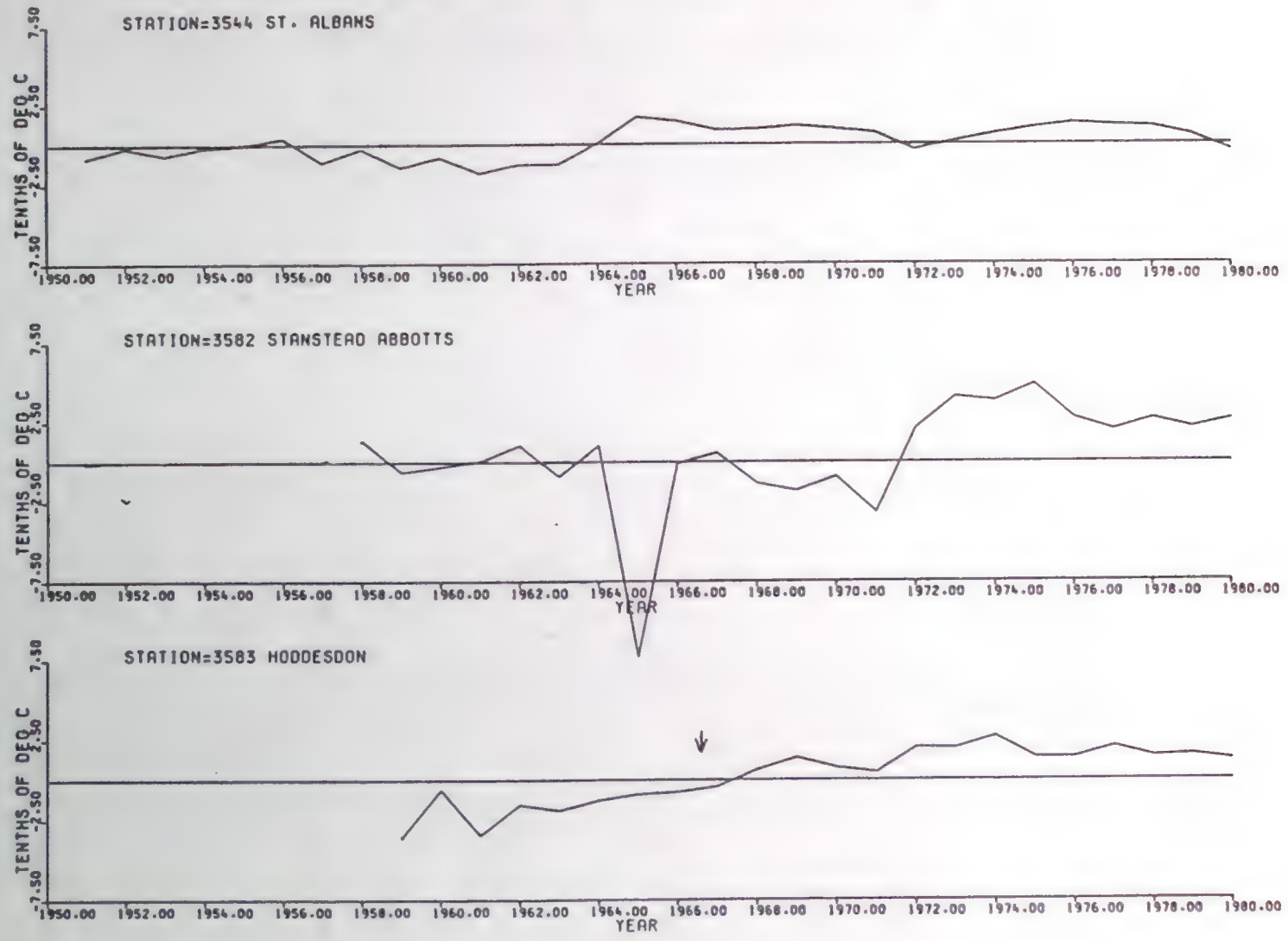
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE



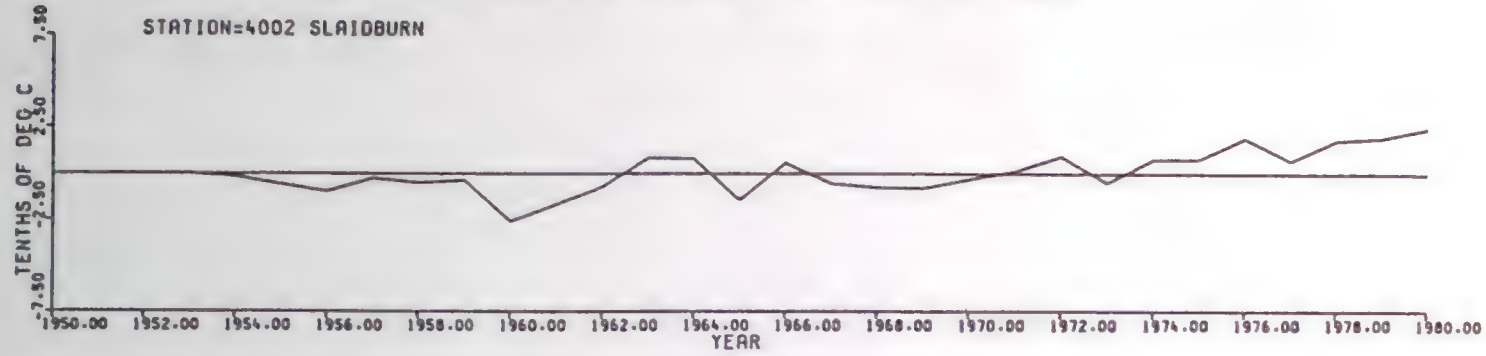
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE

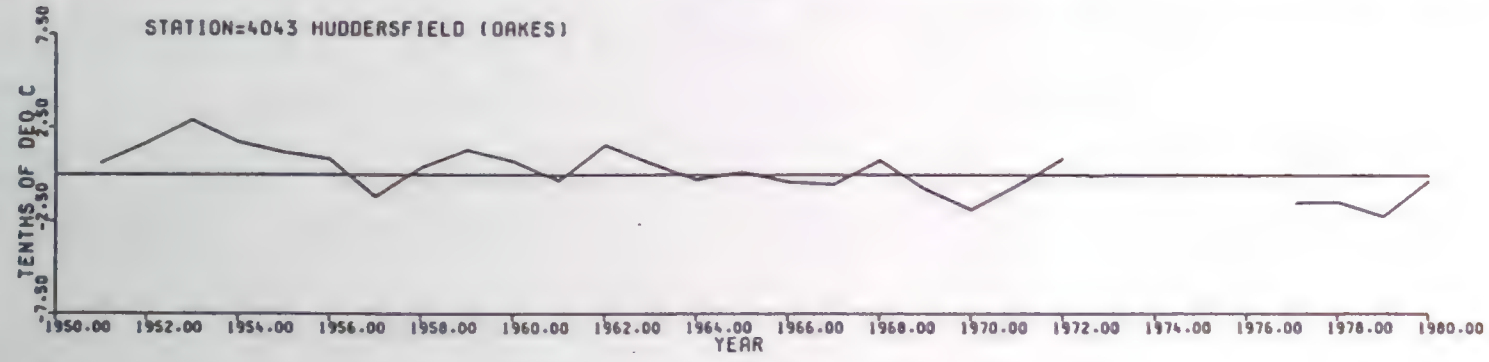


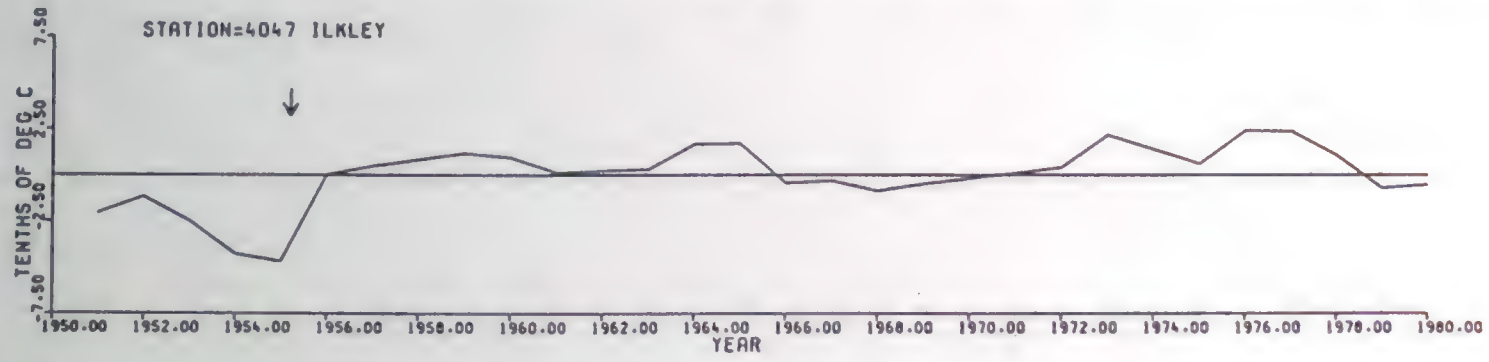
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE

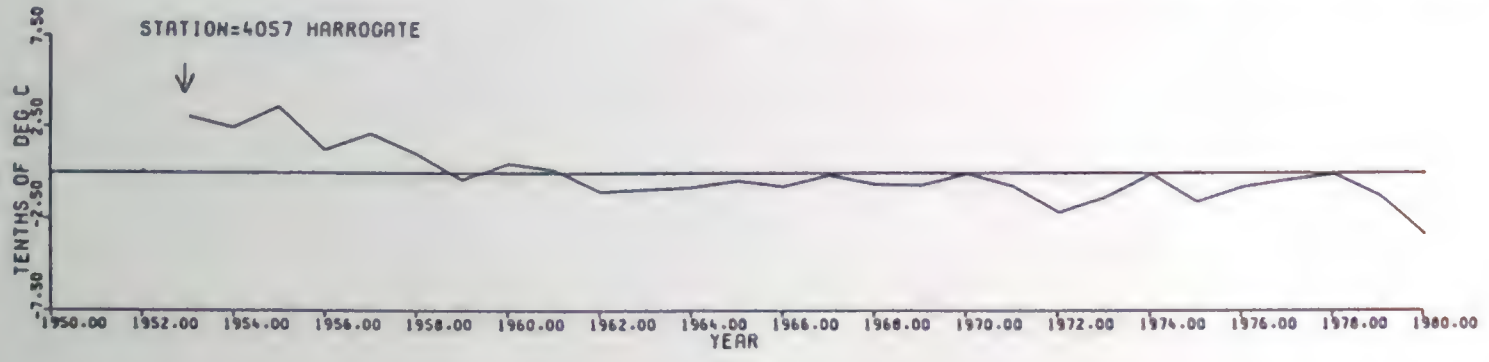


MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE

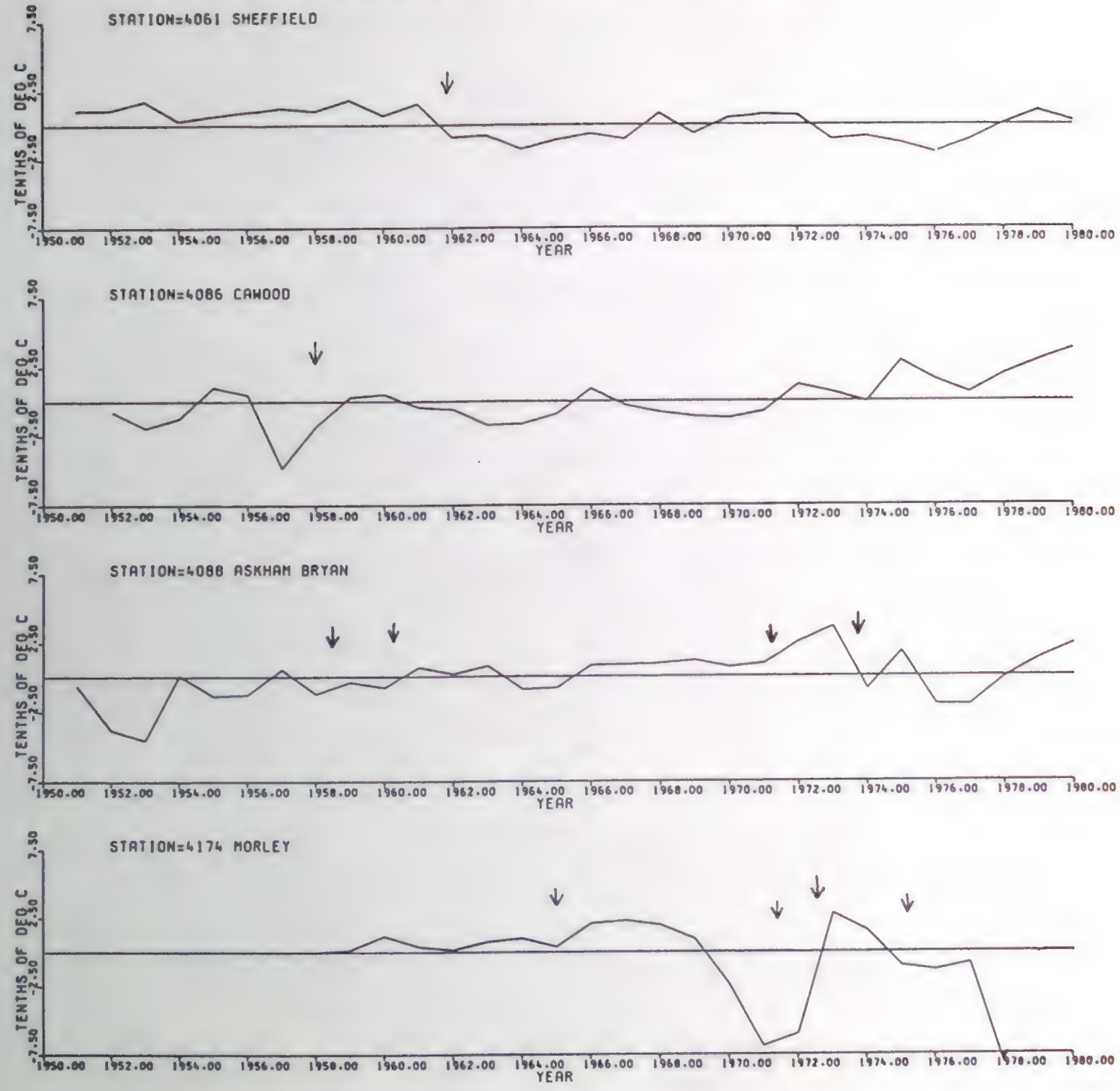




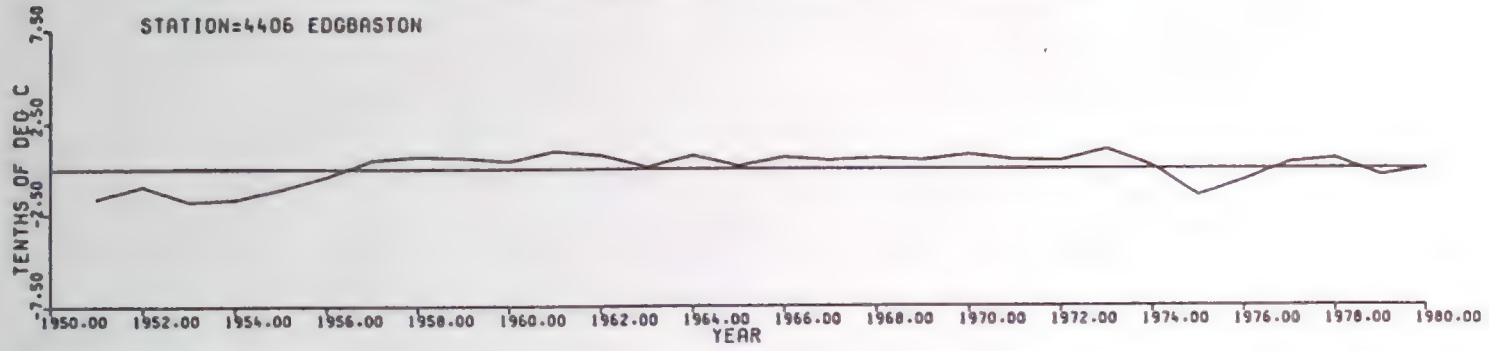


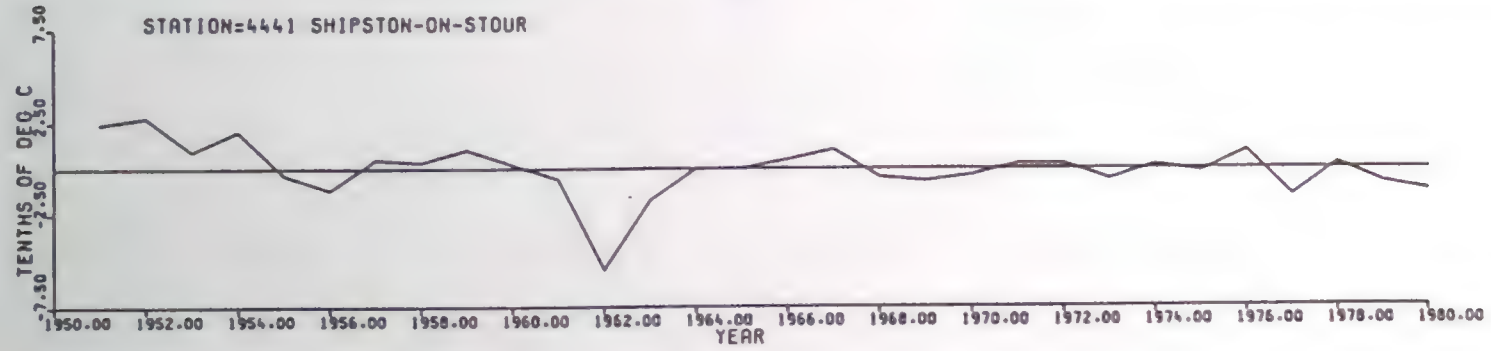


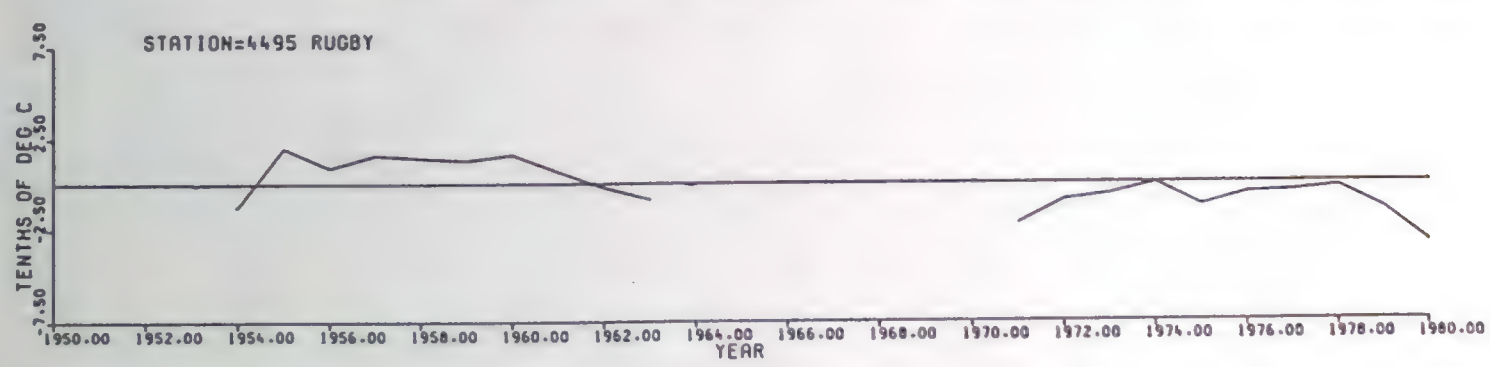
MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE

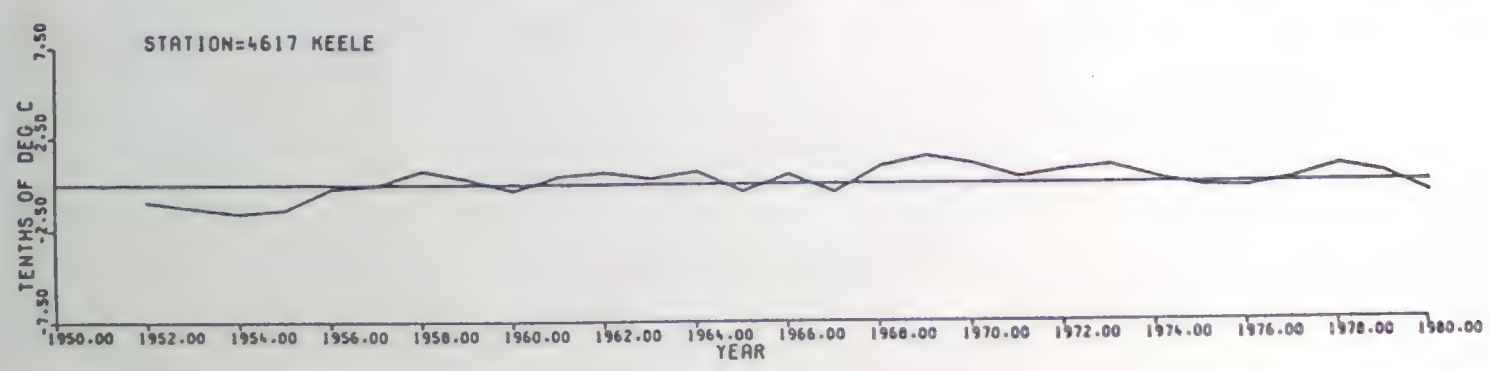


MEAN ANNUAL RMS RESIDUALS FOR MINIMUM TEMPERATURE









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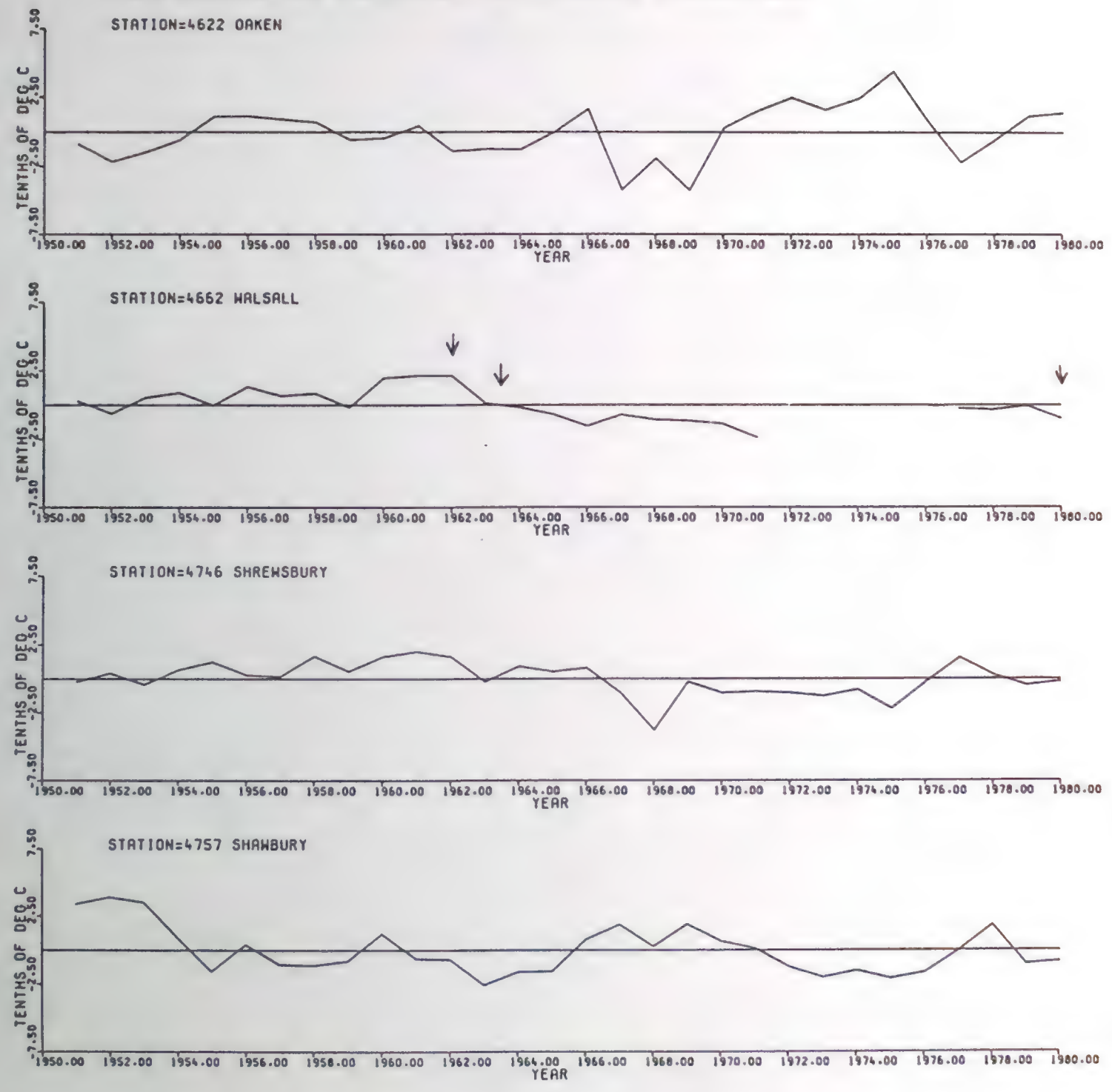

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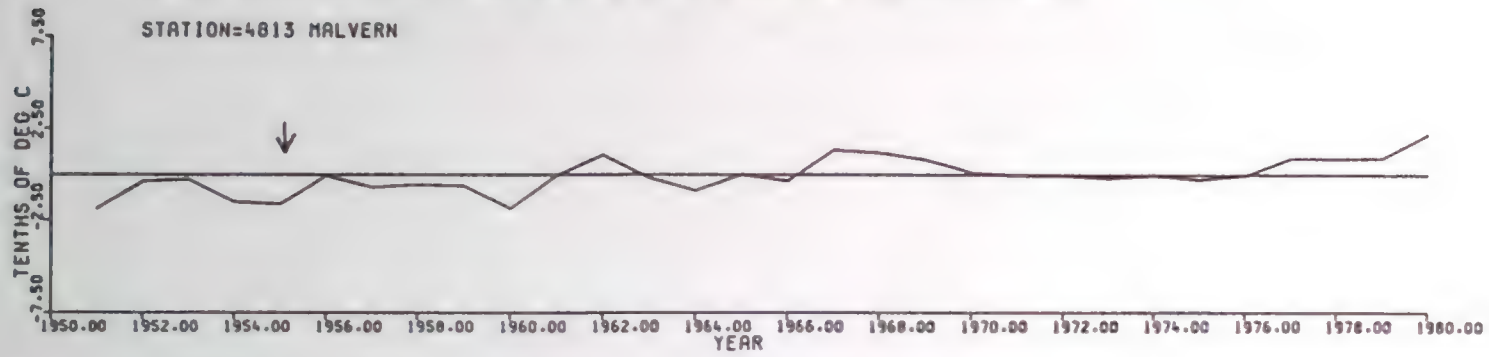

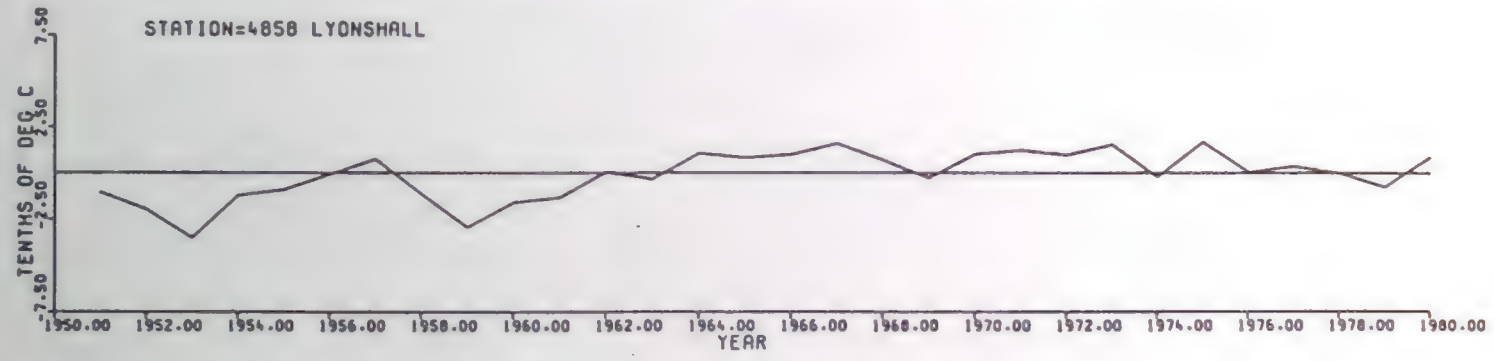

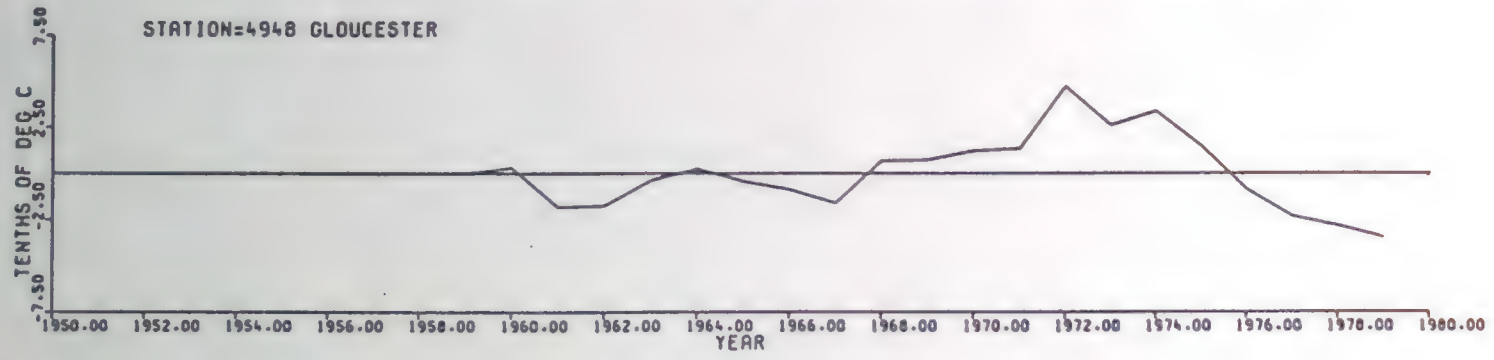

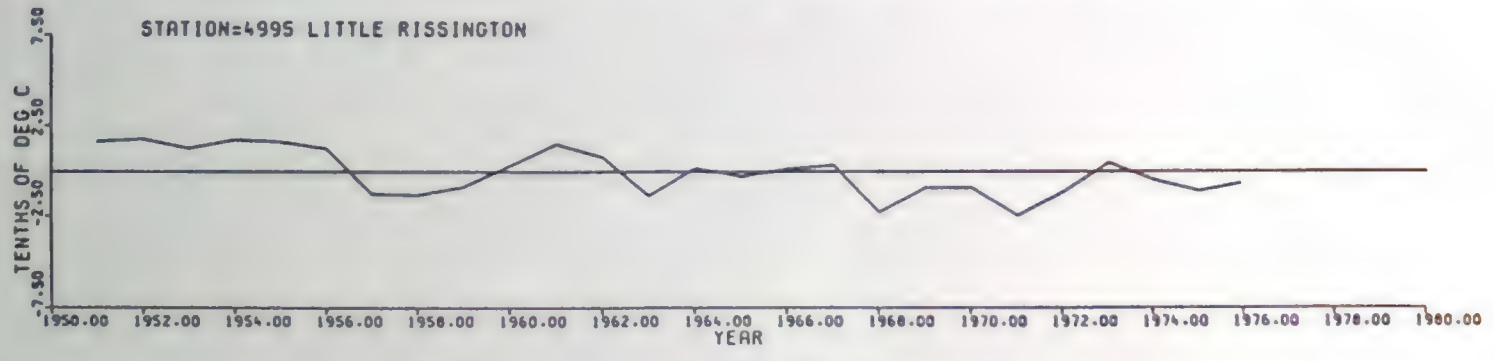

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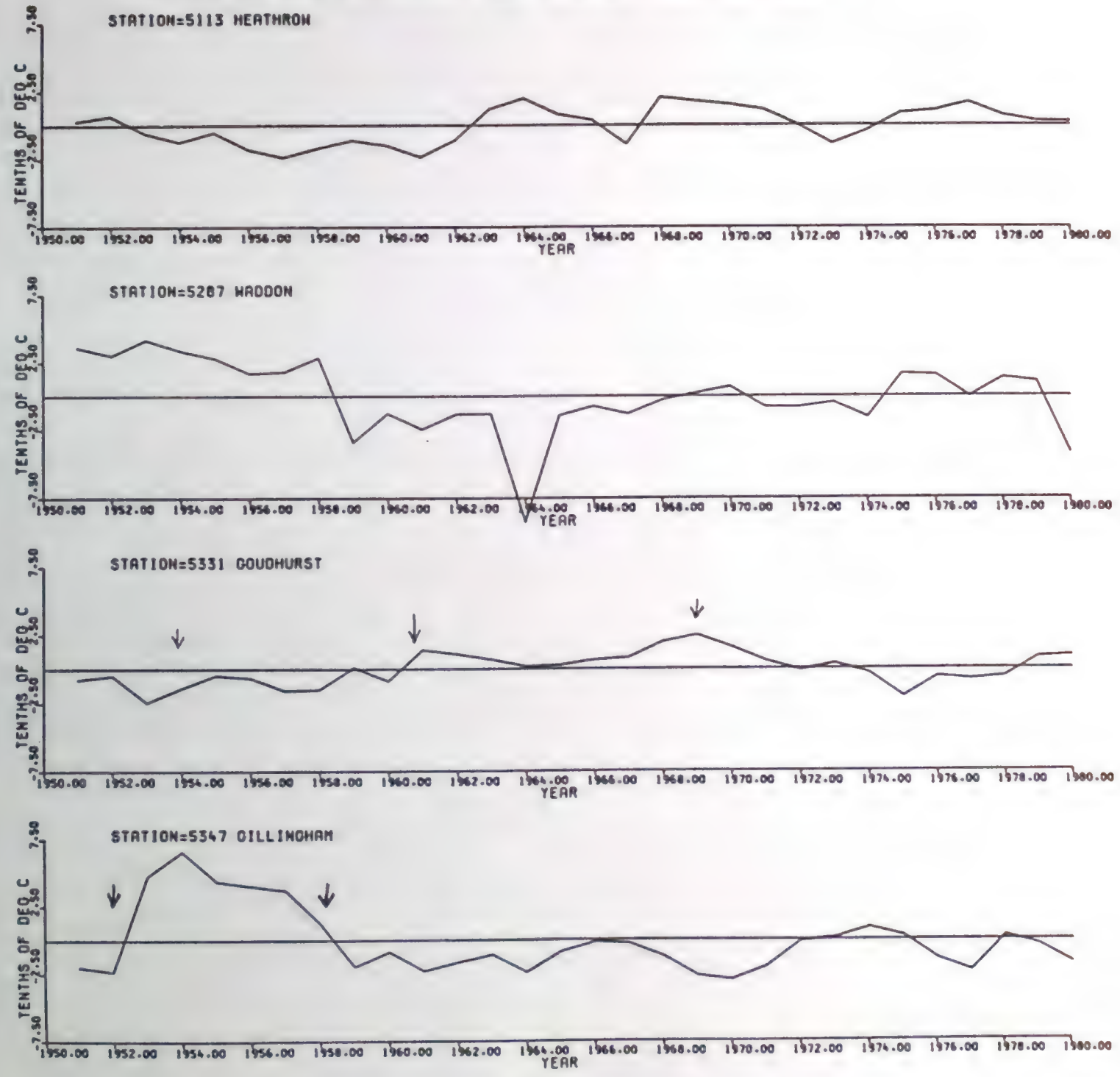

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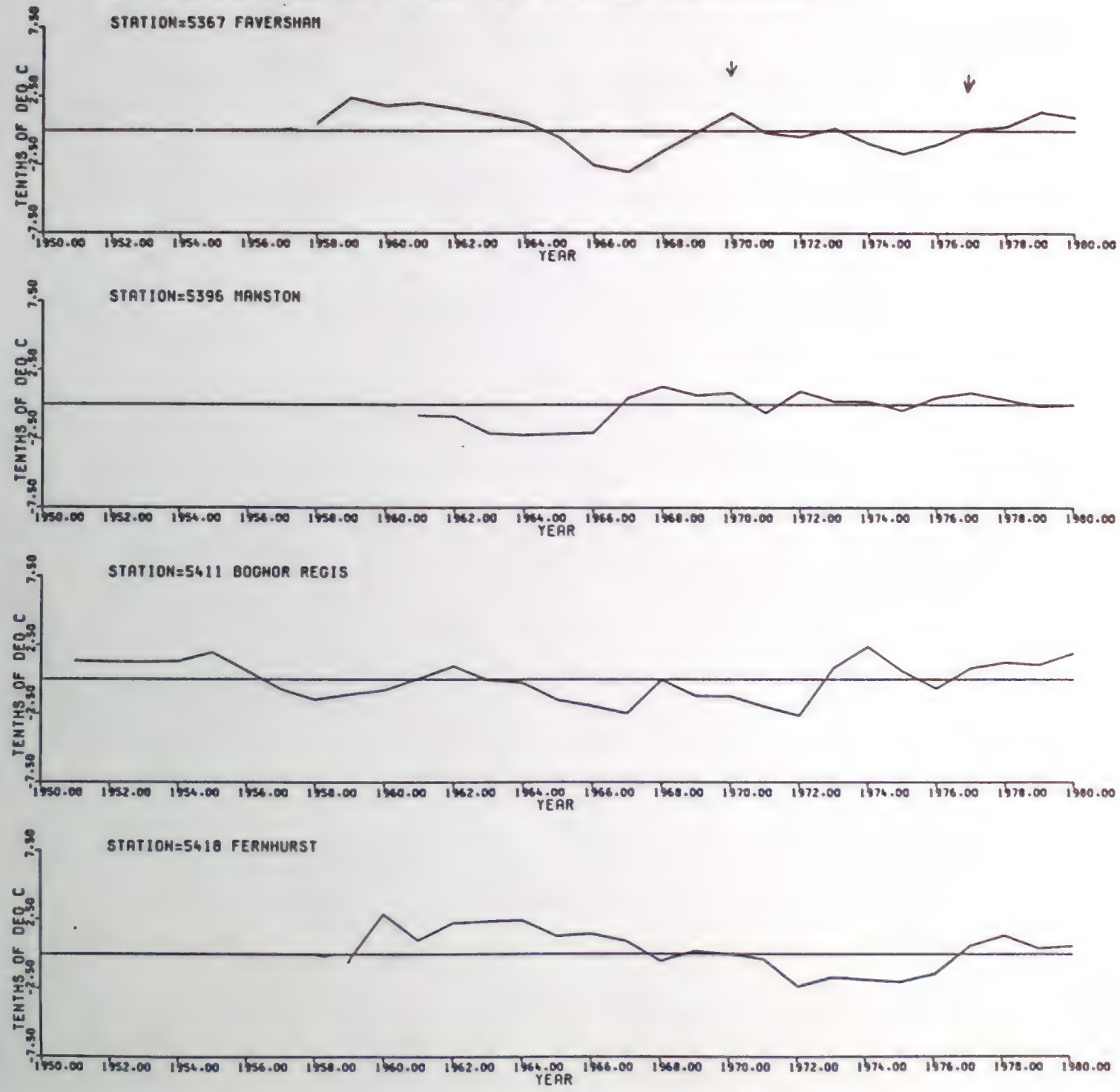

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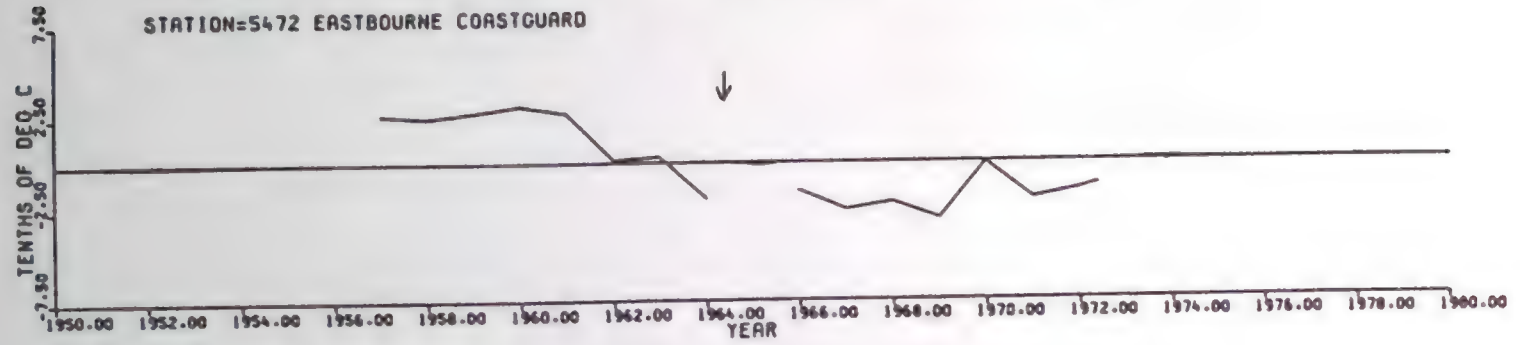

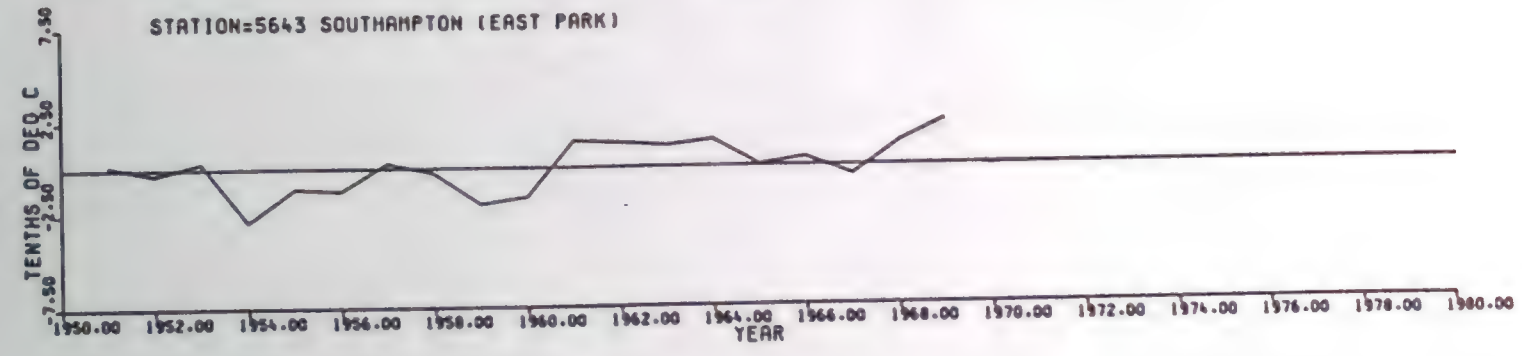

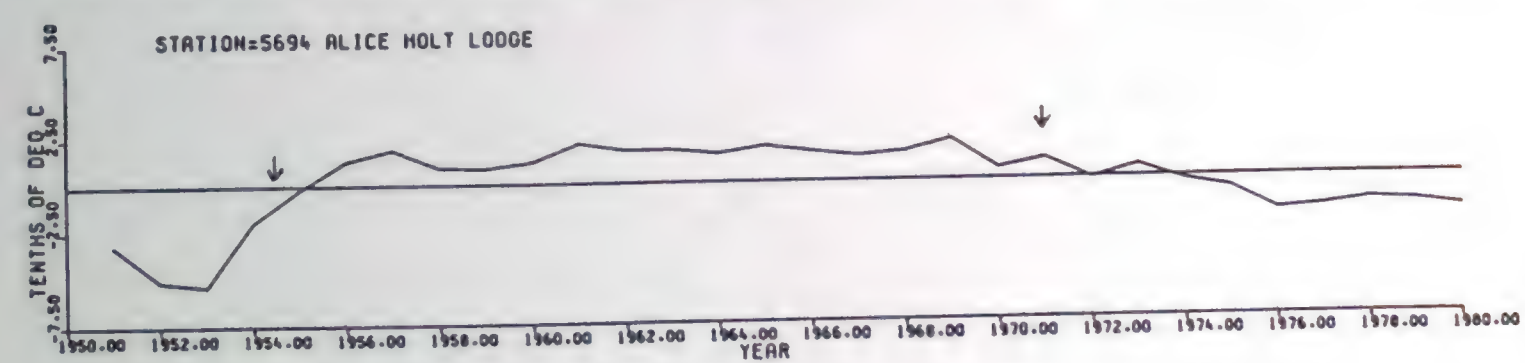

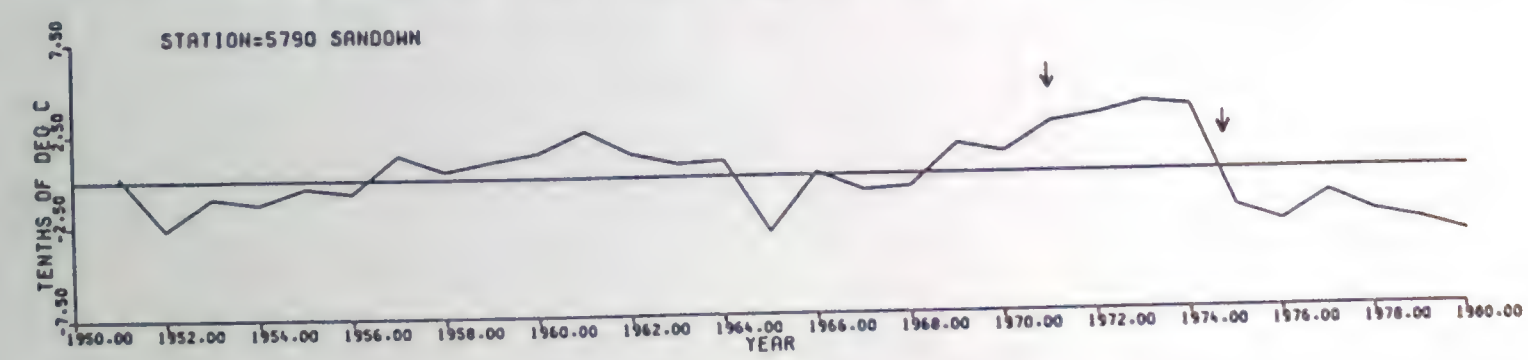

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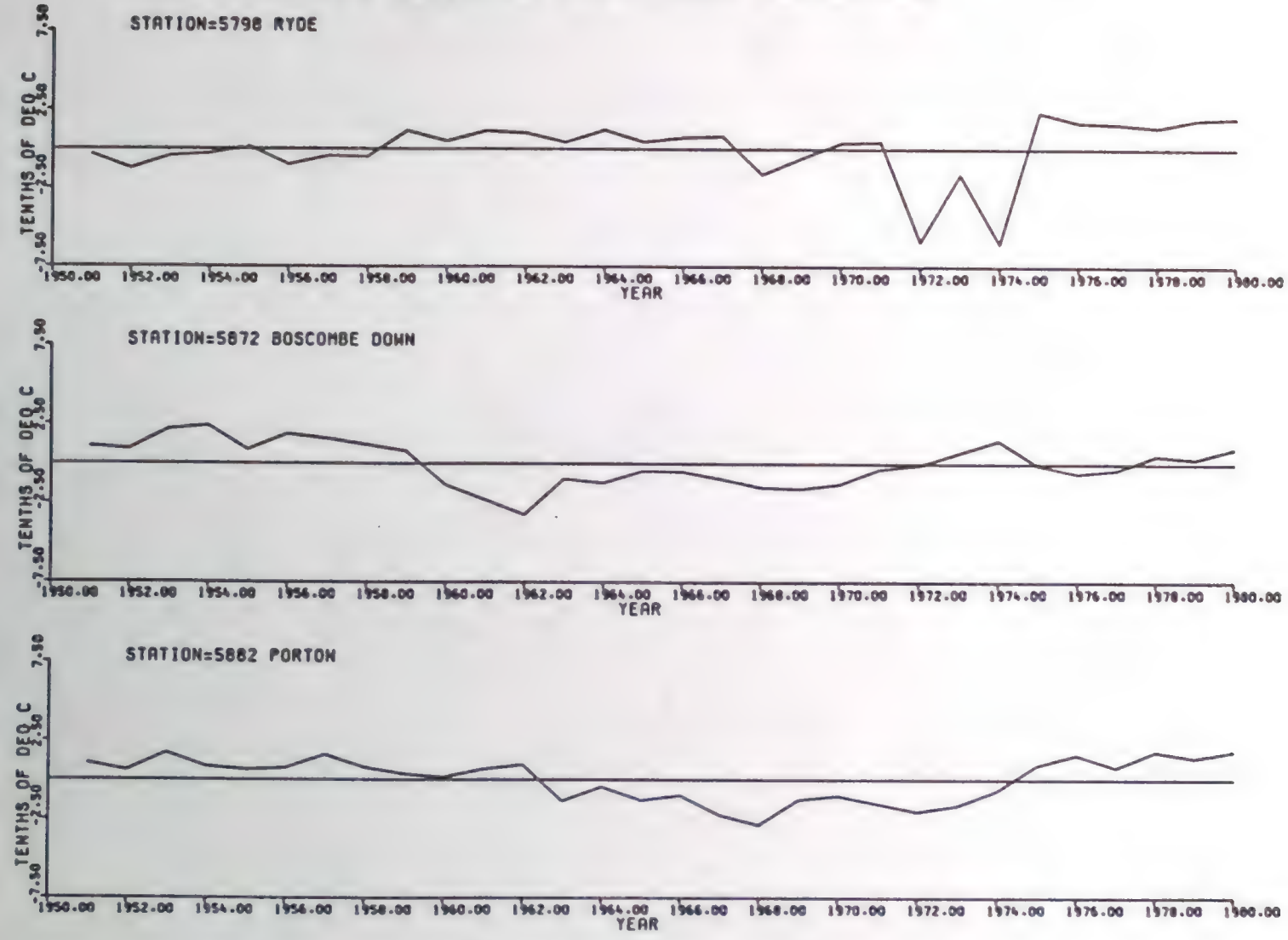

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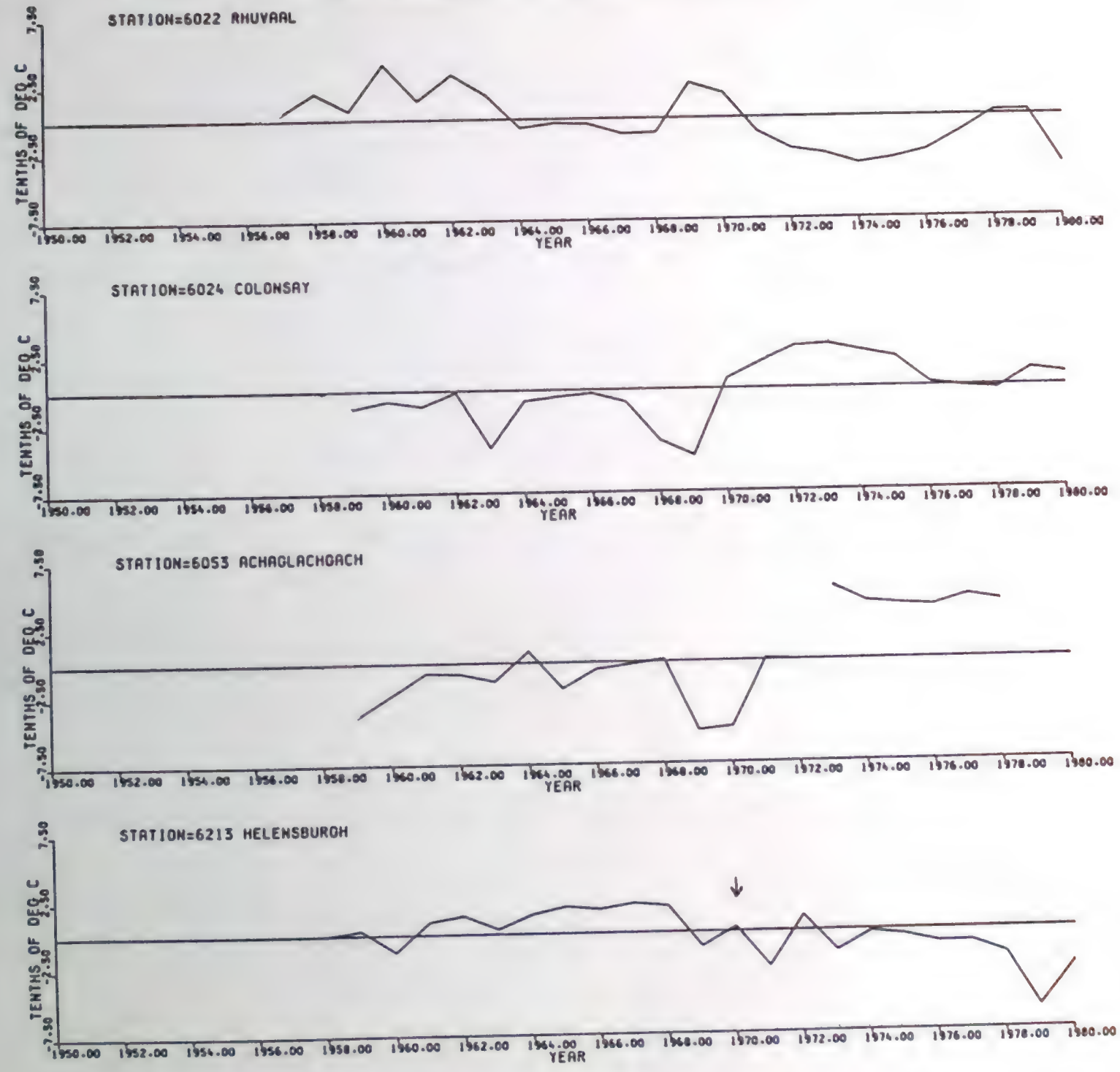

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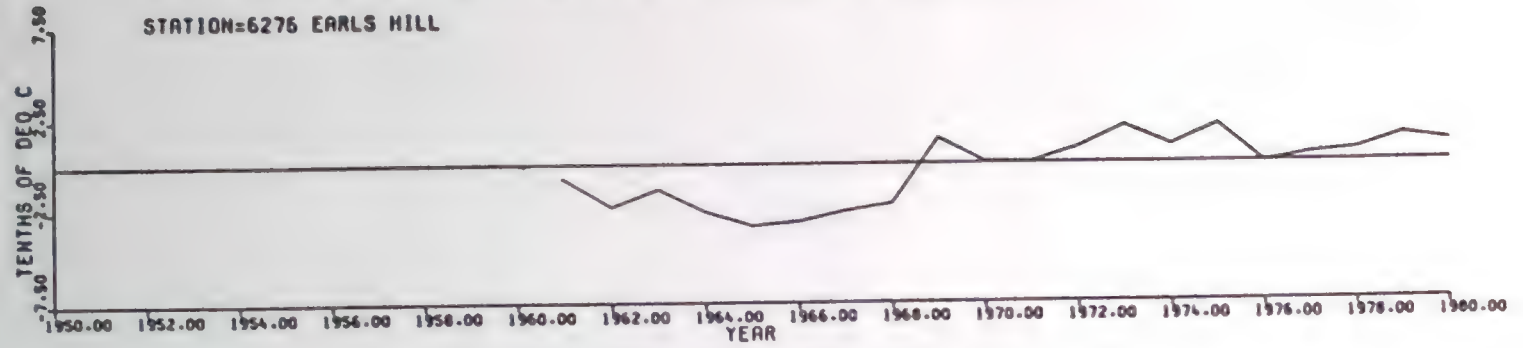

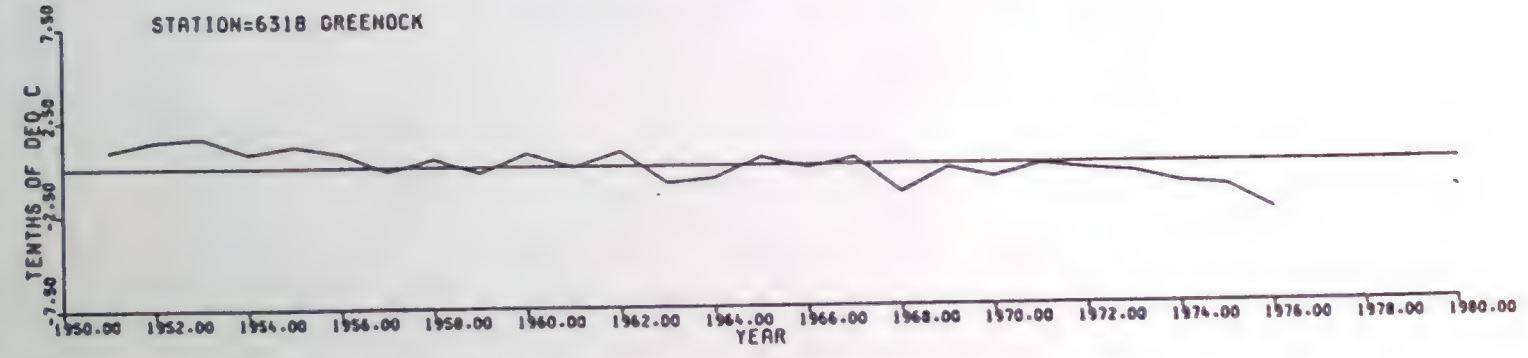

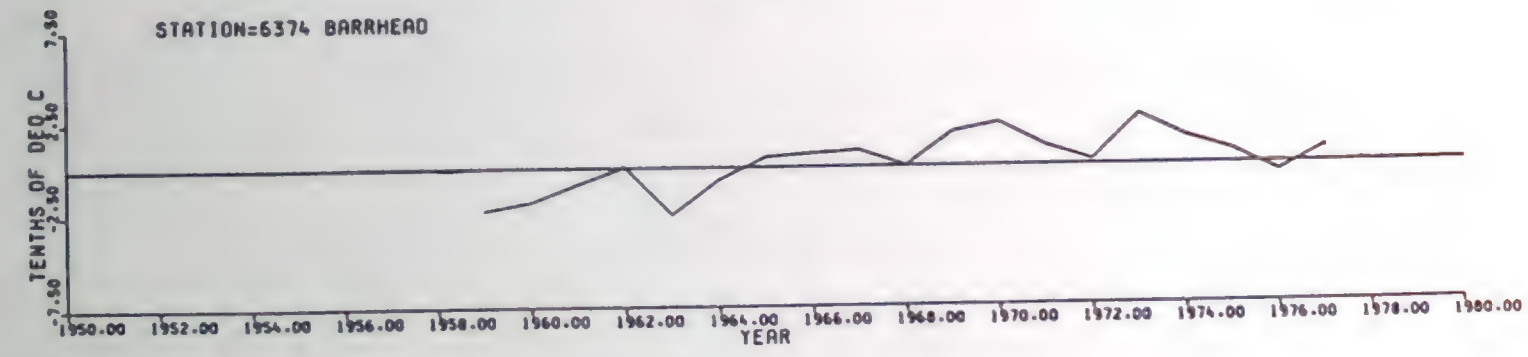

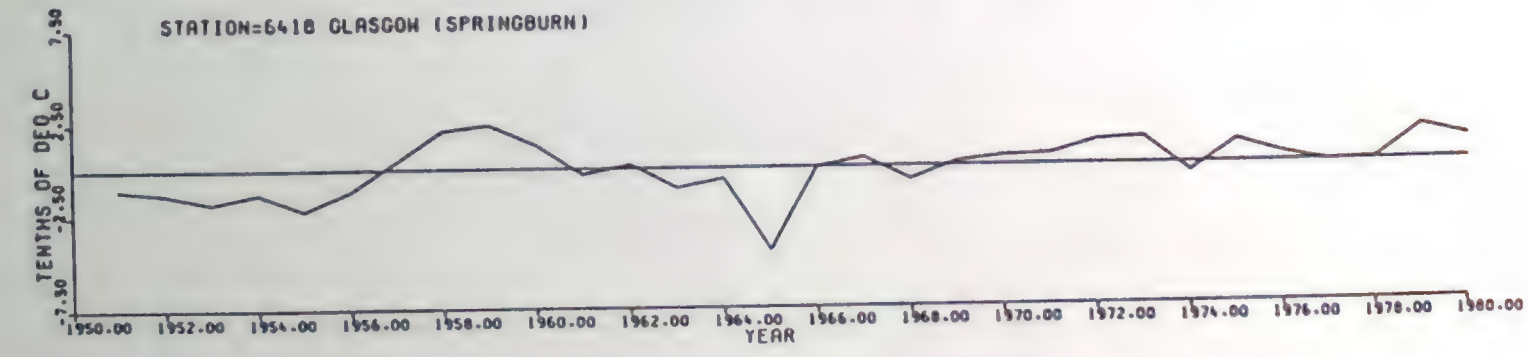

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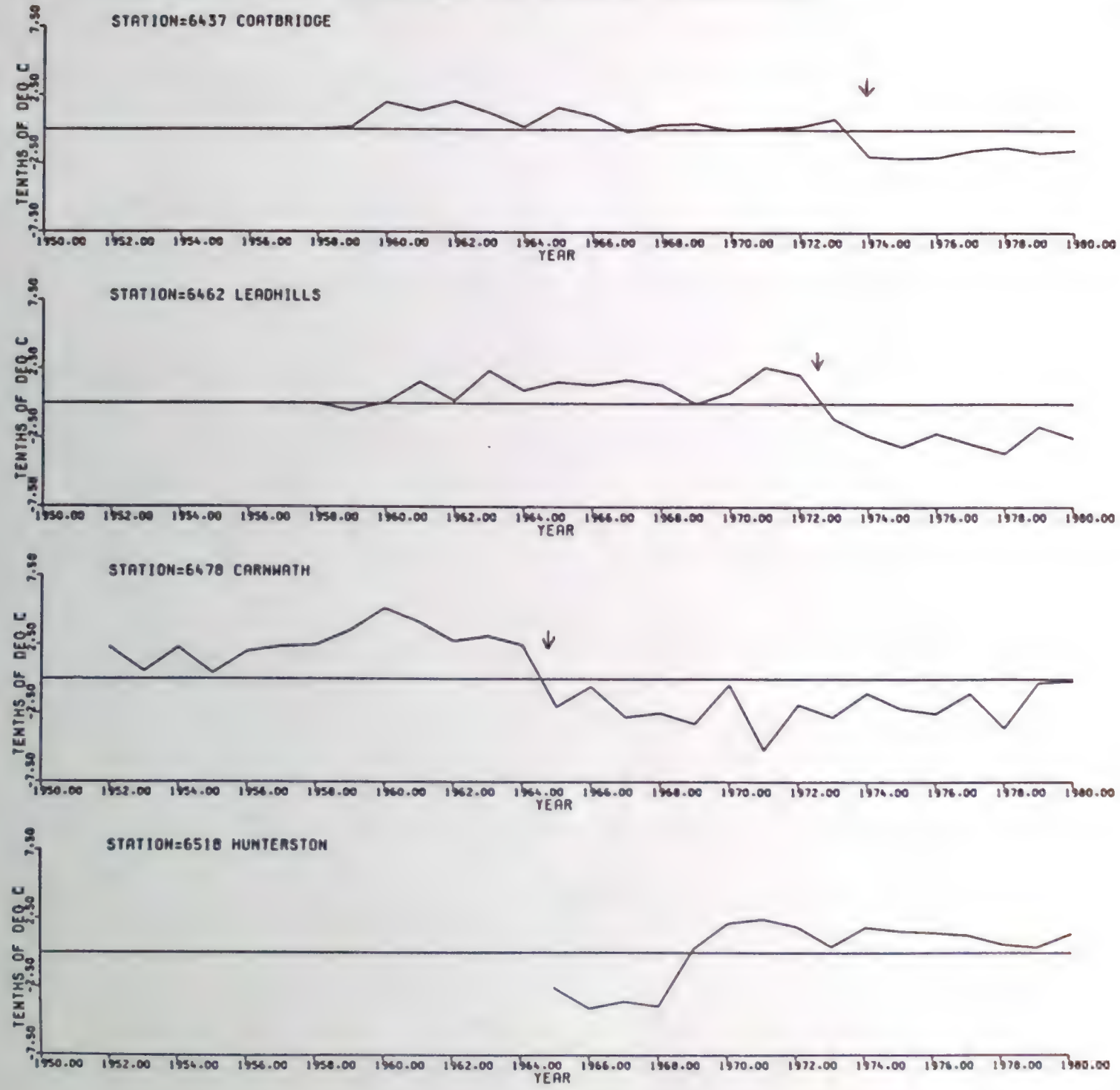

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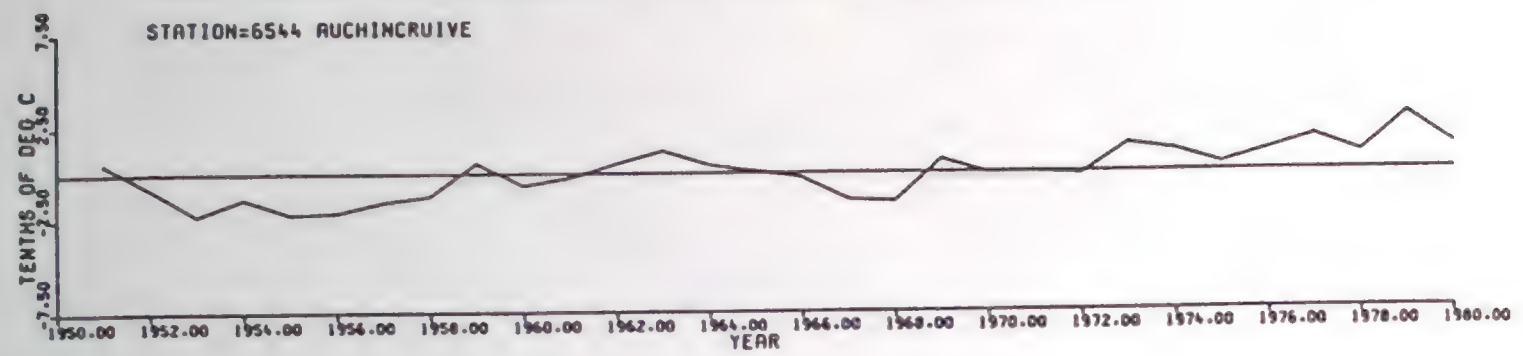

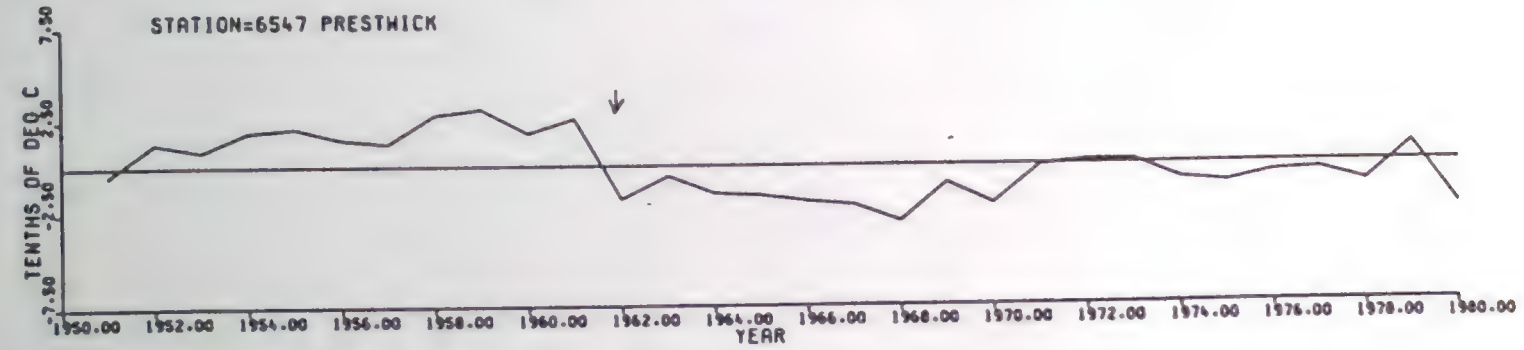

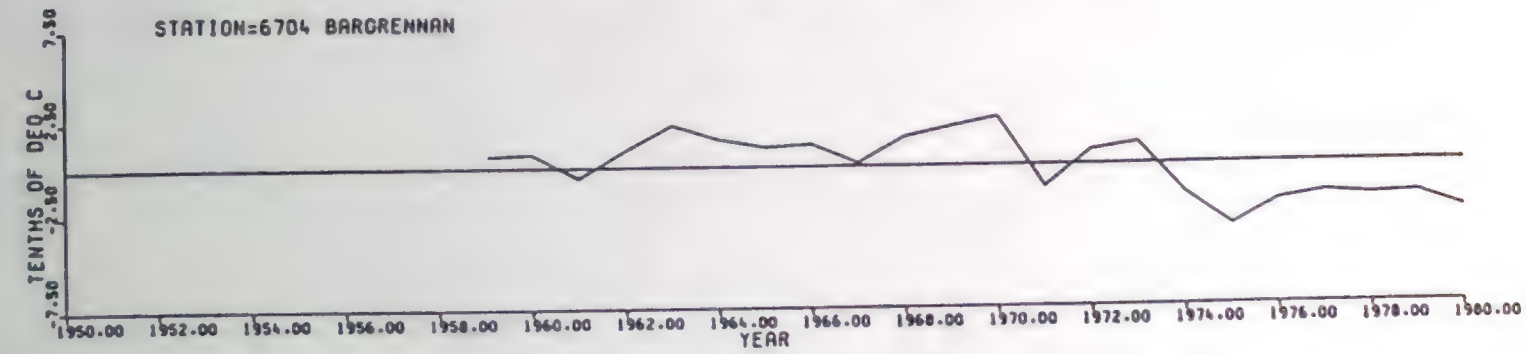

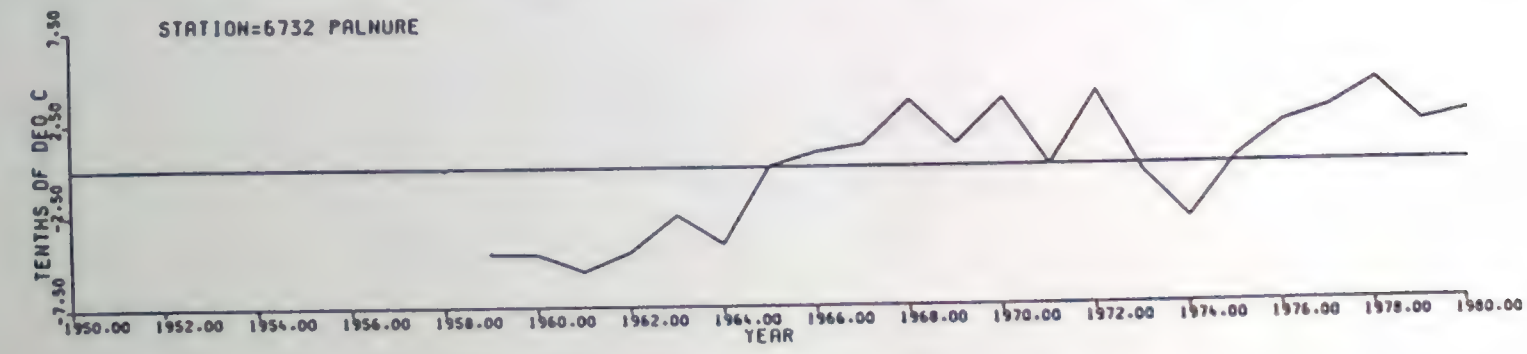

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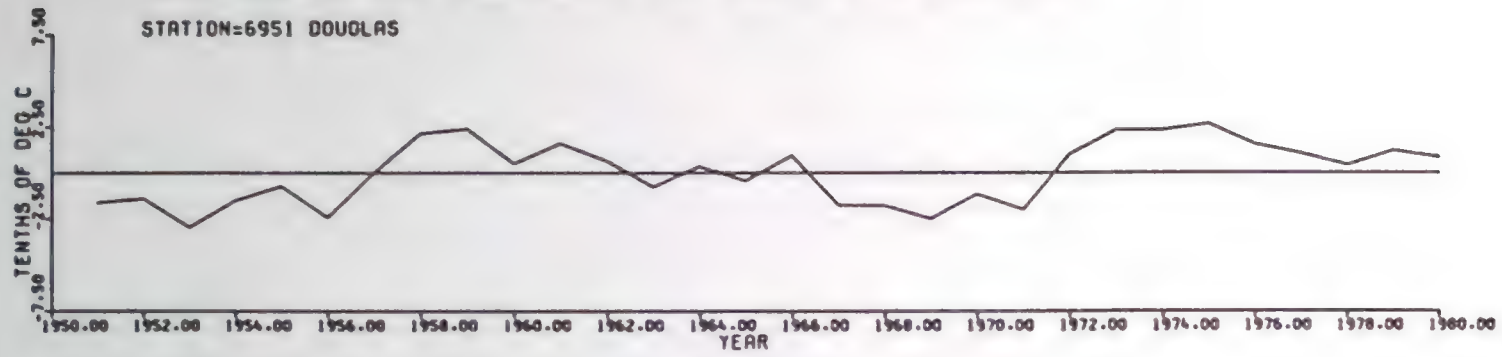

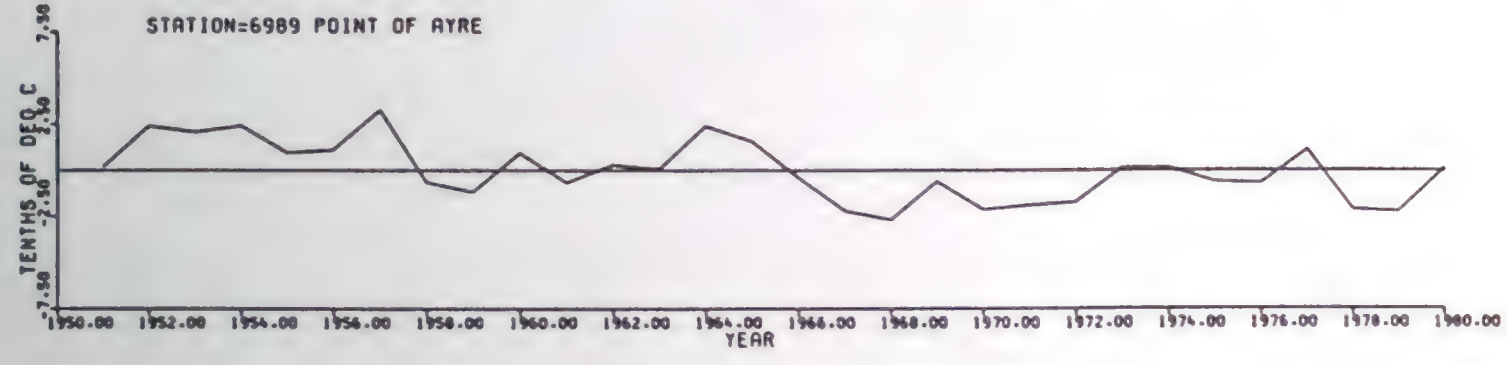

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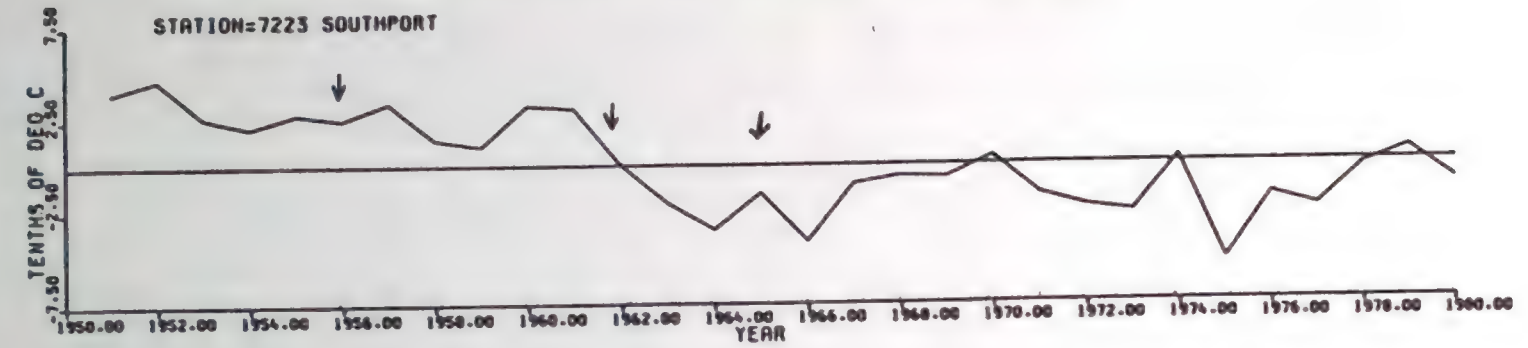

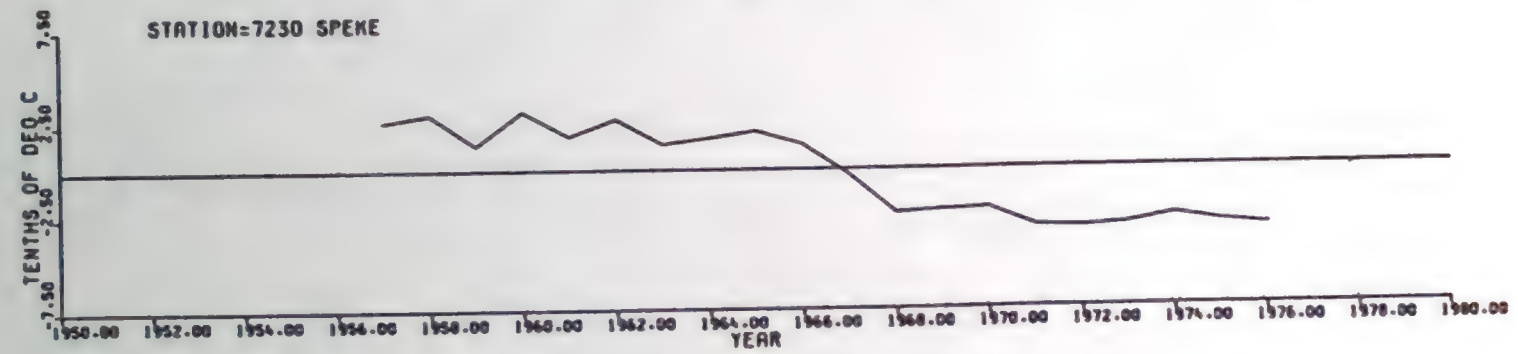

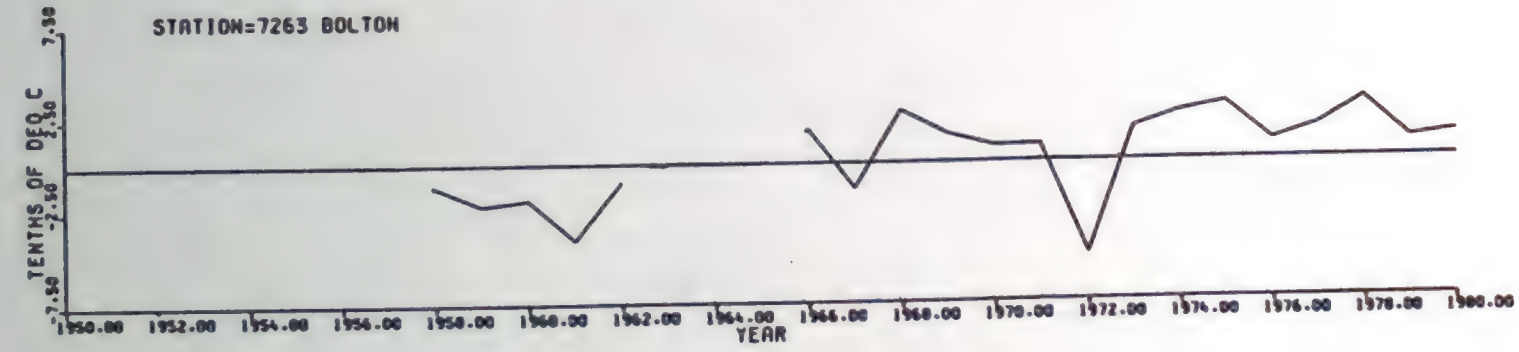

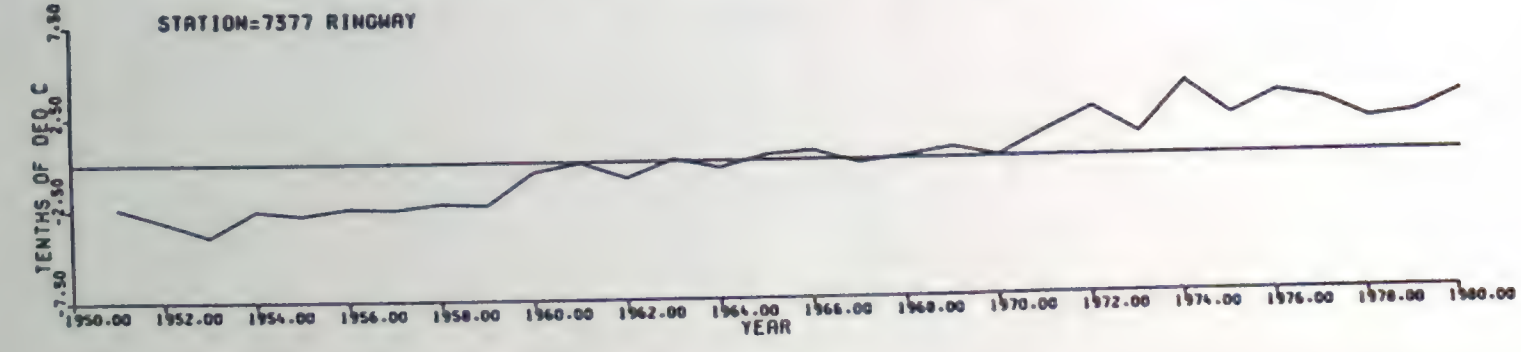

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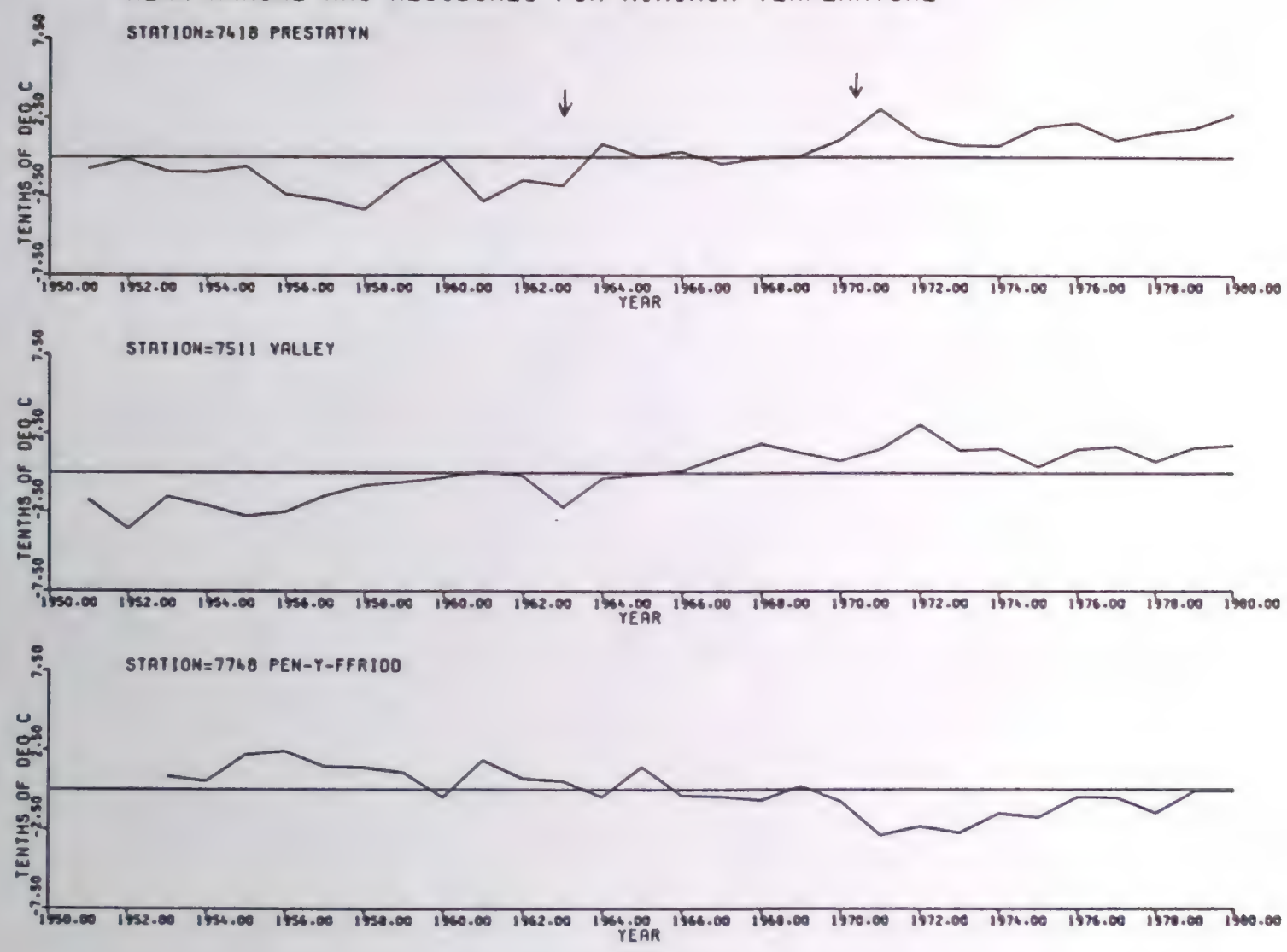

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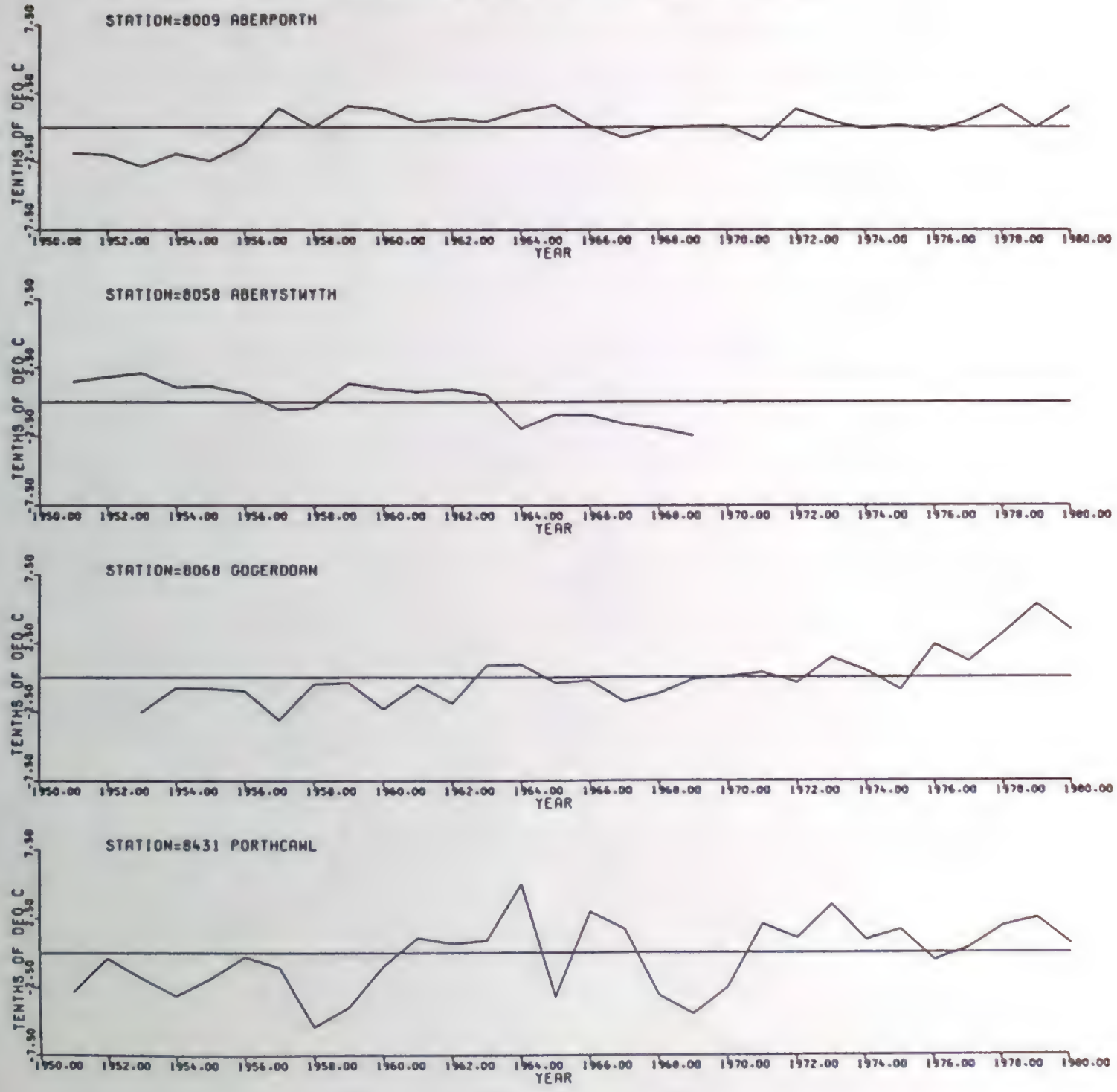

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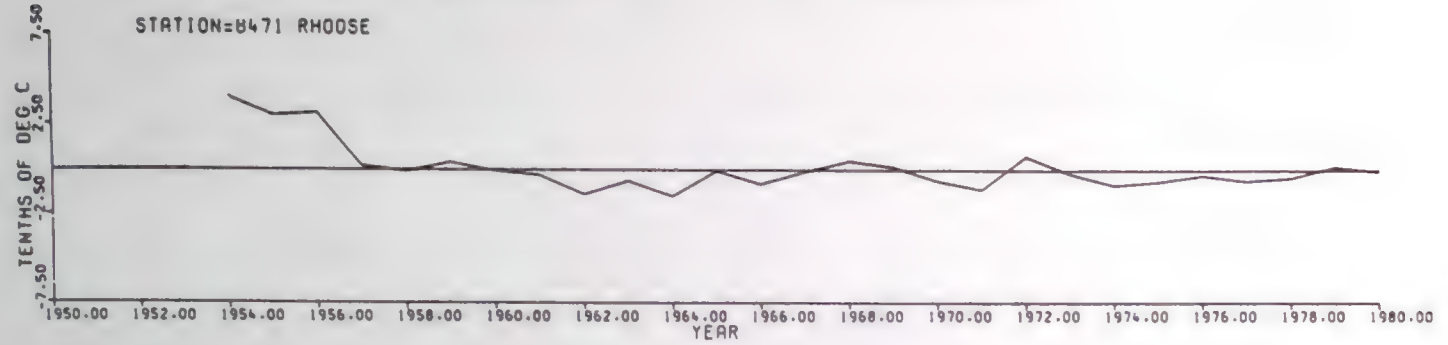

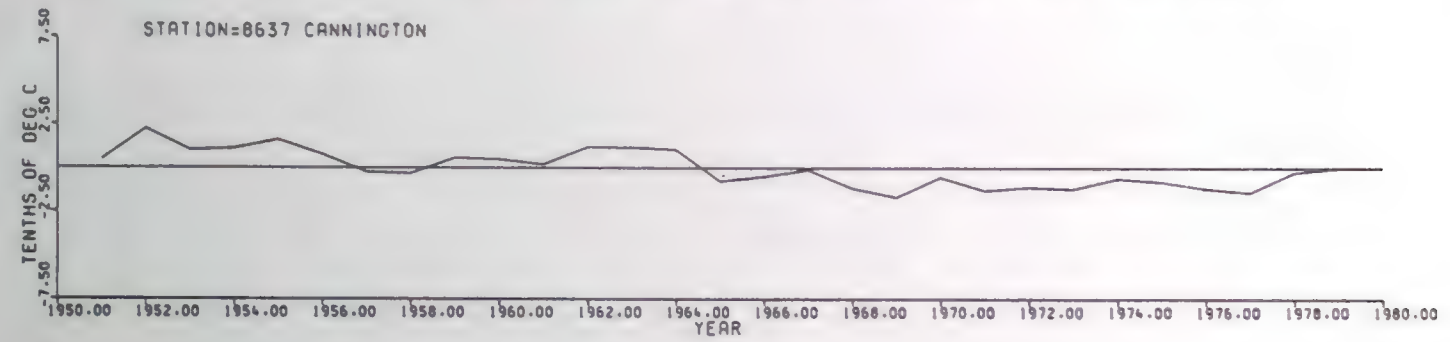

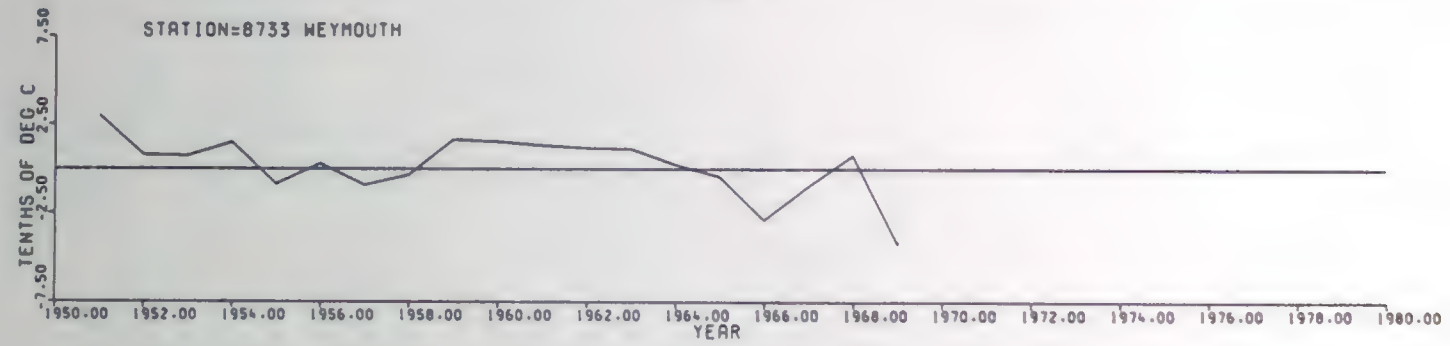

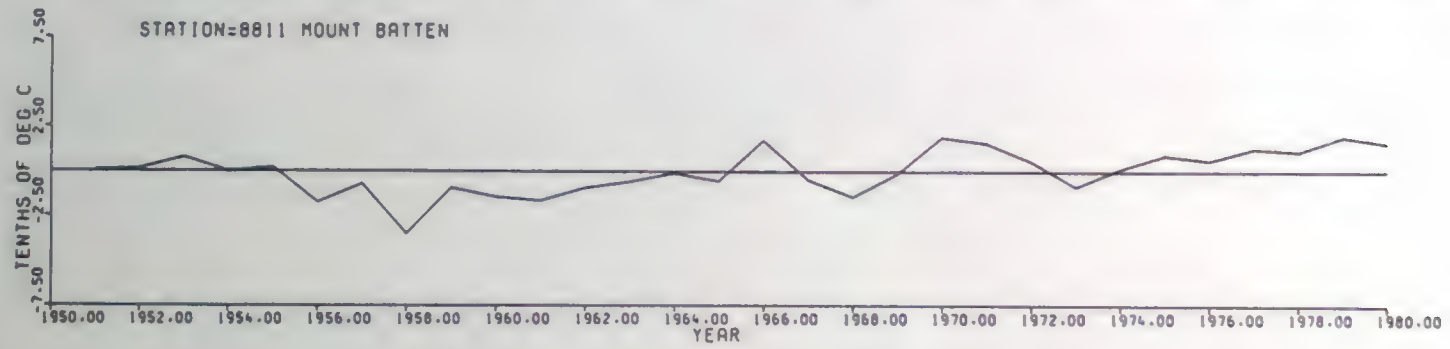

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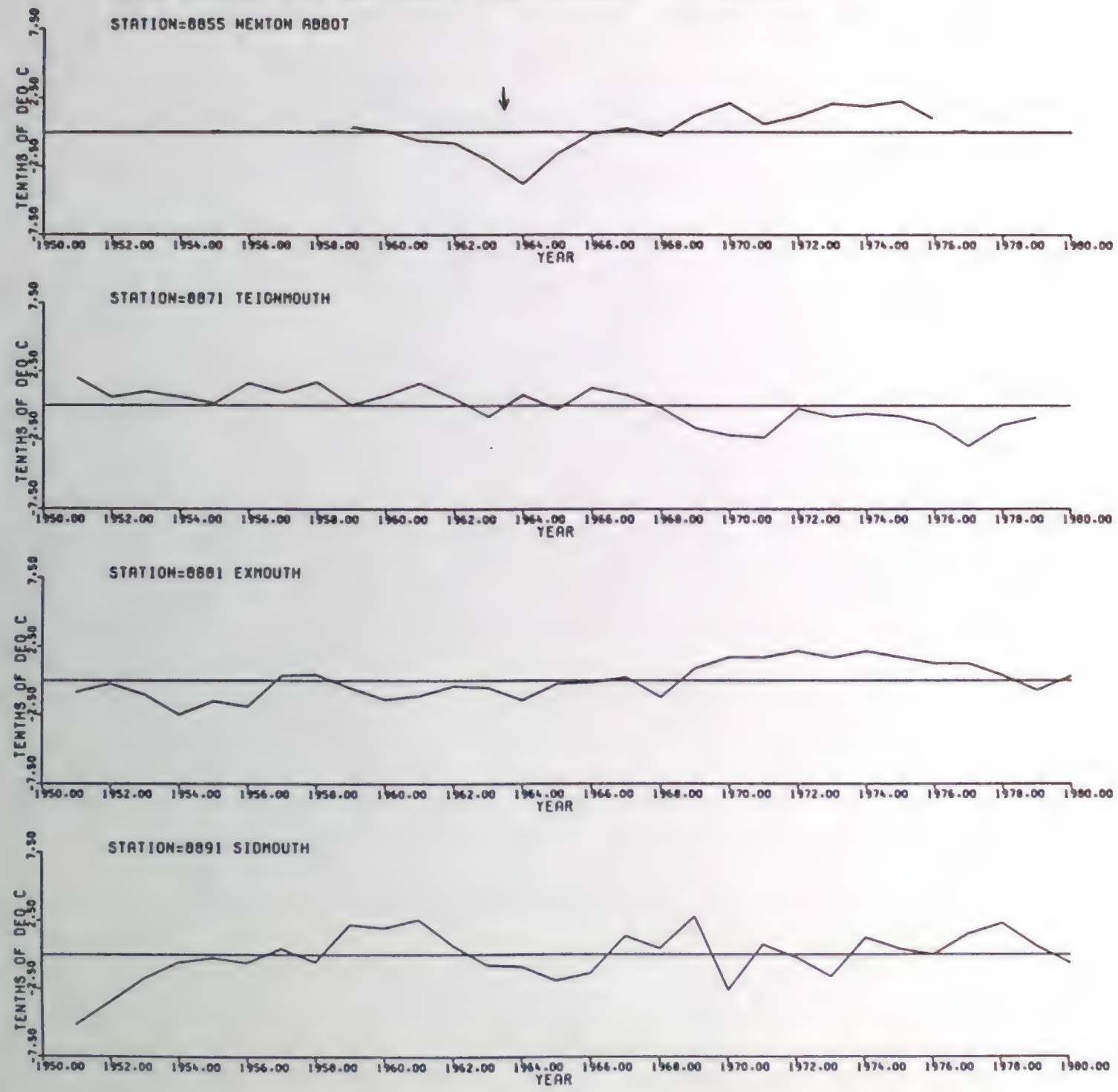

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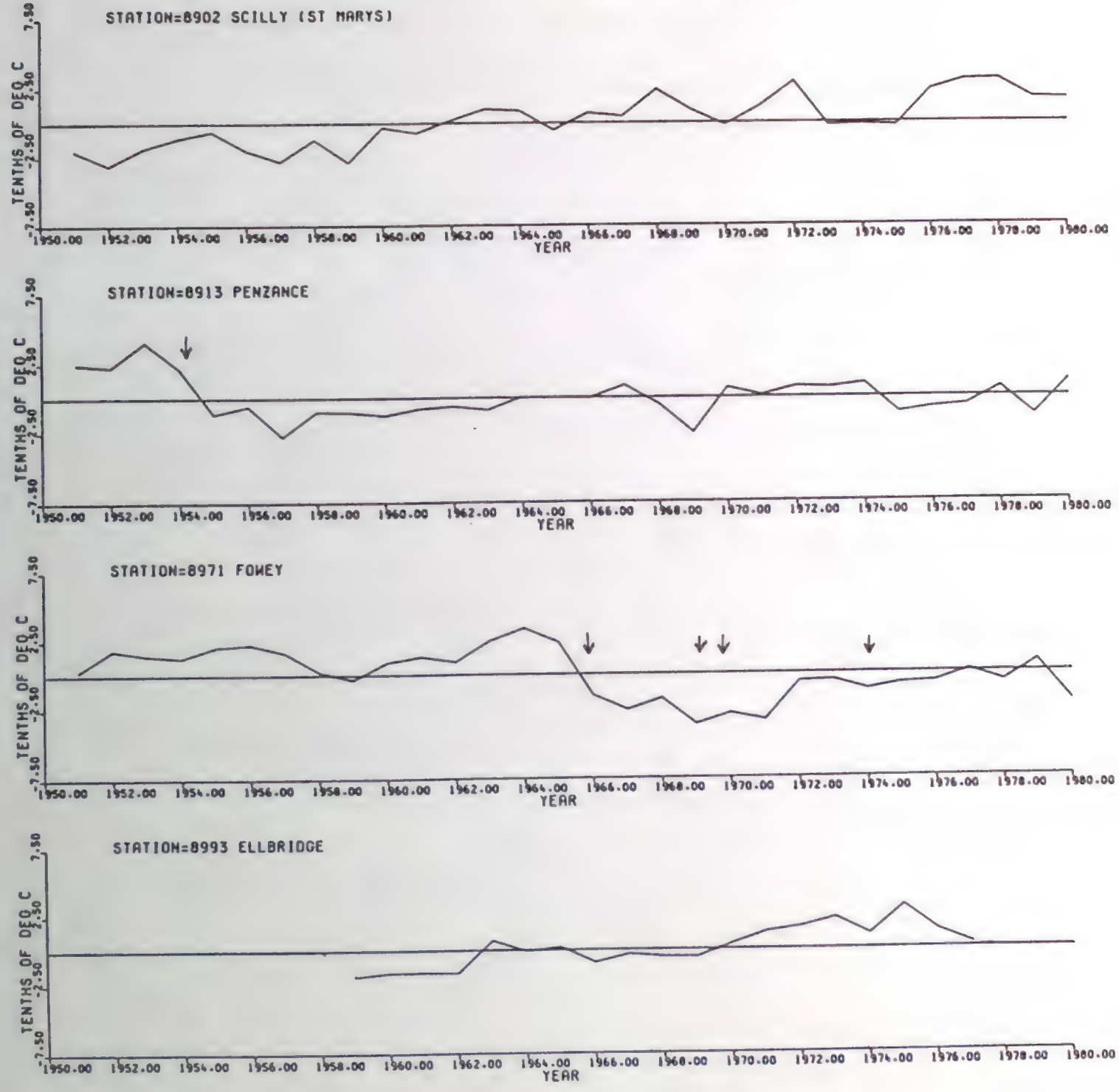

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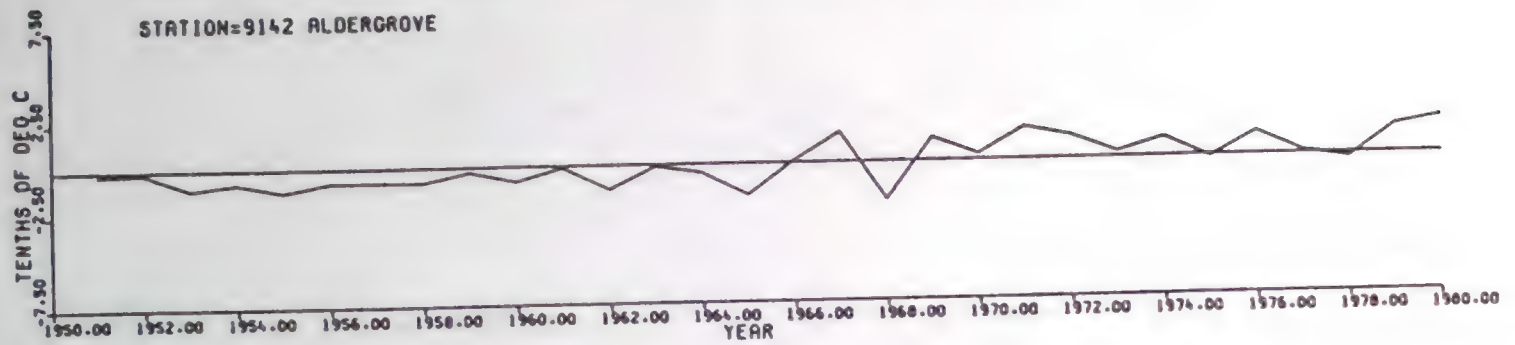

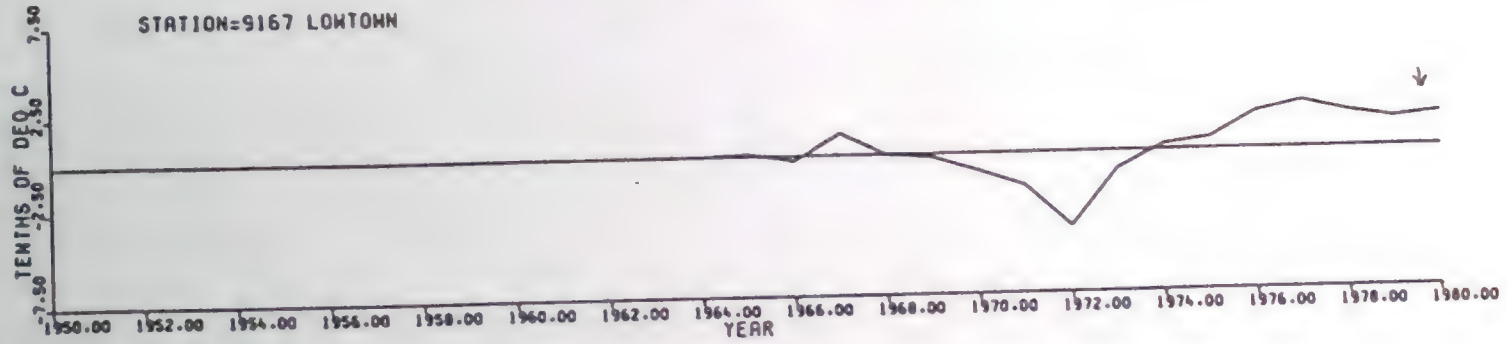

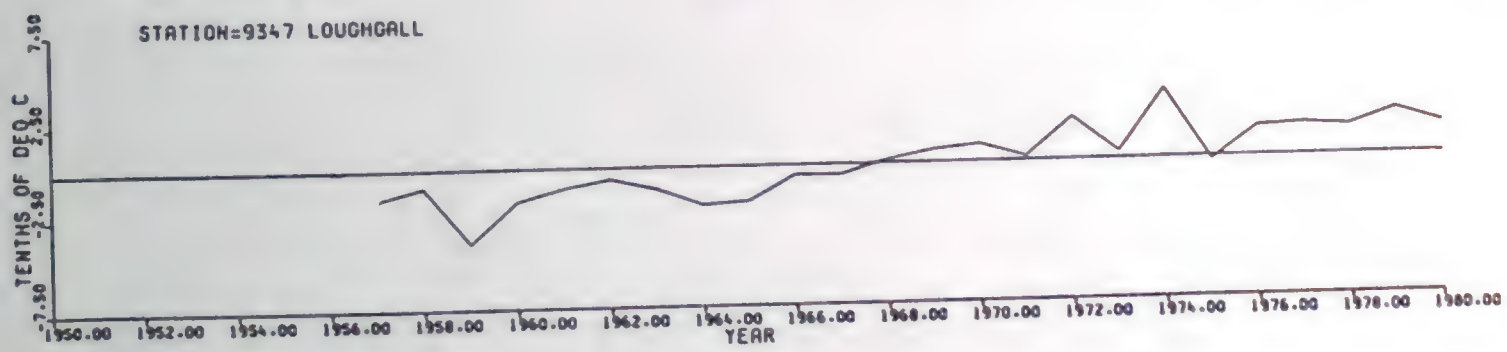

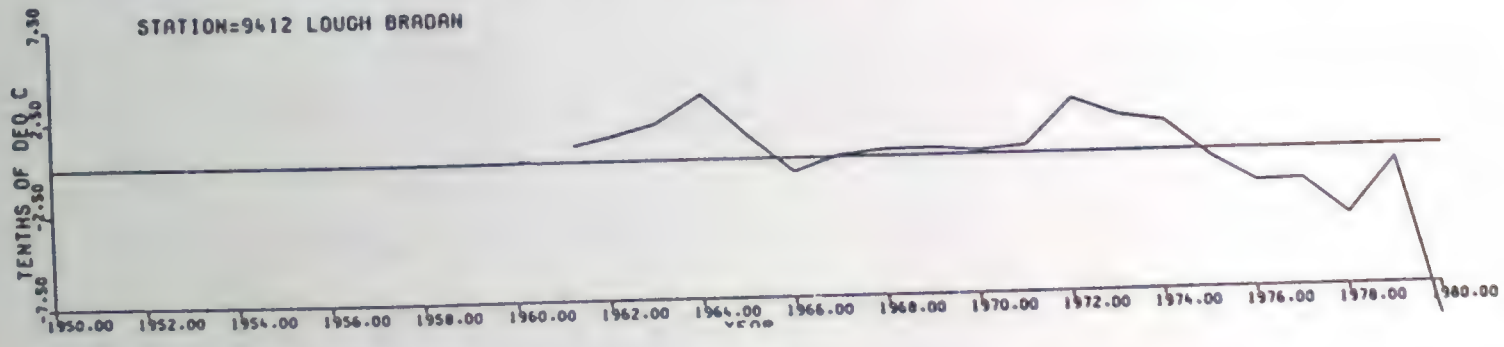

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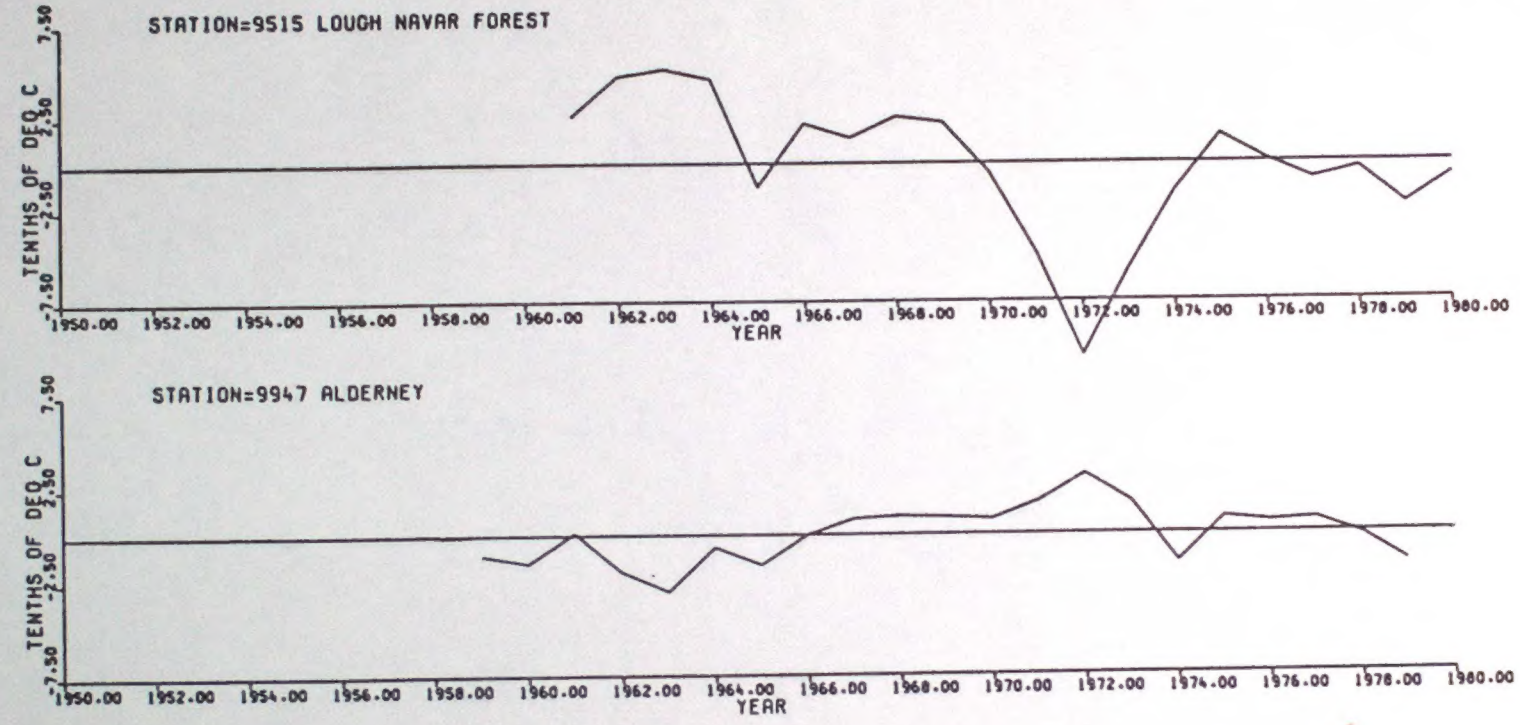

APPENDIX C Revised documentation for program QDHOMO

Program QDHOMO

Source MO3.BRANCH.FORT(QDHOMO)

Object MO3.BRANCH.OBJ(QDHOMO)

Programmer F.A.Crummay

Date January 1986

Purpose To monitor the homogeneity of climatological data in conjuction with the production of 30 year averages.

Method A principal component analysis is performed on the dataset from which missing values must have been estimated. The data are estimated using 8% of the components for temperature and 12% for sunshine. A Time series of the residuals is formed and divided into two subsets (ie first 5 years, last 25; first 10 years, last 20, ... first 25 years, last 5). The means of these subsets are compared using a t-test and a flag raised if the value exceeds a specified critical level (ISIG).

Input The routine has been devised to operate on a data set (30 years x 12 months) of climatological data. Such data sets are produced in conjuction with the production of 1951-80 averages and described in MO3 Technical Note No. 16 (pt B).

Input data consists of the following inter*4 variables.

IVAR - defines the mode of analysis to be performed = 0 for variable = station, 1 if variable = month.

IAVE - defines the type of anomaly input into the PCA, = 0 for 'station' anomaly, 1 for 'local' anomaly, 2 for 'monthly' anomaly.

IPRINT - 1 to print all results, = 0 to print selected results.

IF1R, ILAS - first and last district to be analysed (ie if IFIR = 0 and ILAS = 0, district 0 studied ; IFIR = 0, ILAS = 1, districts 0 + 1 studied).

IDAR - determines the percentage of estimated data permitted 1 = 50%, 2 = 30%.

ITYPE - 1 to illustrate inhomogeneous stations, = 0 illustrate all stations.

IMULT - is determined by the type of data set to be analysed, = 1 for max and min temperature, = 2 for sunshine.

ISIG - determines the significance level at which values are to be tested, 1 = 95%, 2 = 90%.

Output

The mean annual residuals of the flagged stations are plotted on CALCOMP film with an option available (ITYPE) to plot the residuals for all stations.

Paper or microfiche output is also produced with, in all cases the mean annual residuals for the flagged stations, together with the t values and eigenvectors/values illustrated.

In addition IPRINT=1 results in the printing of the covariance matrix (15 by 15 variables), the monthly estimates (following PCA) and monthly residuals.

JCL

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//LKED.PBS DD DSN=MET.PROGLIB,DISP=SHR
//LKED.FAC DD DSN=MO3.BRANCH.OBJ,DISP=SHR
//LKED.CAL DD DSN=MET.CALCOMP,DISP=SHR
//LKED.MO3OBJ  DD DSN=MO3.BRANCH.OBJ,DISP=SHR
//LKED.SYSIN DD *
        INCLUDE FAC(QQMESK,QDHOMO)
        INCLUDE PBS(GPRW,MWRIT)
        INCLUDE CAL(CALCOMP,LINE,SCALE,AXIS)
        INCLUDE MO3OBJ(GSTNDTL)
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//GO.FT07001 DD  SYSOUT=A,DCB=(RECFM=FB,LRECL=131,BLKSIZE=1310)
//GO.ARCHIV10 DD DSN=MO3.QQTMINM,DISP=SHR
//GO.FT08001 DD SYSOUT=G,DCB=(RECFM=FB,LRECL=80,BLKSIZE=1680)
//GO.FT99F001 DD DSN=ML.CLMASTR,DISP=SHR
//GO.SYSIN DD *
   0 2 0 0 0 2 1 1 1
//
```

Underlined sections to be changed if necessary.